M2mpower
Application Guide

Sony Ericsson

Contents

1 Introduction 4
1.1 Purpose of Guide 4
1.2 Who Should Read This Guide? 4
1.3 Prerequisites 4
1.4 Related Documentation 5
2 Software Features 9
2.1 M2mpower Integrated Development Environment 9
2.2 PC Specification 9
2.3 Overview 9
2.4 The IDE Software 10
2.4.1 Installing the IDE Software 10
2.4.2 Getting Started with IDE 11
2.4.3 Using the IDE software 11
2.5 Library Toolbar 14
2.5.1 M2mpower IDE 15
3 How is the script embedded? 17
3.1 Environment 17
3.2 Limitations 18
4 Script Interpreter 19
4.1 Overview of the Script Interpreter 19
4.2 Interpreter Language 19
4.3 Limitations 19
4.4 5 Steps to Application Production 20
4.4.1 Writing a script 20
4.5 Script Memory Storage 21
5 Support 22
6 Intrinsic Function Library 23
6.1 Level 1 Functions 23
6.2 Level 2 Functions 25
6.3 Level 3 Functions 25
7 Application examples 27
8 Controller Mode 28
8.1 Introduction 28
8.2 Technical Description of Controller Mode 28
8.2.1 Limitations – restricted functionality 29
8.3 Controller Mode Example 30
8.3.1 Running the Example Script 31
8.4 Controller Mode Script {Controller_Mode.sc} 31
9 Keypad and I2C LCD 34
9.1 Introduction 34
9.2 Keypad 34
9.2.1 Operation 34
9.2.2 Set-up 34
9.2.3 Example 36
9.3 I2C LCD 39
9.3.1 Operation 39
9.3.2 Set-up 39
9.4 Fixed Cellular Terminal Application {FCT.sc} 43
10 Demo Board 47
10.1 Demo Board Information 47

10.2 Inputs/Outputs 47
10.3 UART's 48
10.4 Thermistor 48
10.5 Miscellaneous 48
10.6 Demo Board Script {Demo_Board.sc} 50
11 MBUS - Metering Application 53
11.1 Overview 53
11.2 MBUS support in Embedded Applications 53
11.3 Implementation 53
11.4 Hardware Setup 54
11.5 The Script 54
11.6 Testing the Application 54
11.7 Flexibility 55
11.8 Metering Application Script {MBUS.sc} 56
11.9 References 59
12 Using the Embedded Application TCP/IP Functions for Data Exchange 60
12.1 Overview of Embedded Applications TCP/IP 60
12.2 Basic Usage of TCP/IP Features 60
12.2.1 Protocols 60
12.2.2 GPRS Transport for IP 61
12.2.3 Flow of TCP/IP Operations in a Script 61
12.2.4 TCP Connect Operations 61
12.2.5 Testing Communications over TCP/IP 62
12.3 General Restrictions 62
12.4 Resource Restrictions 63
12.4.1 Packet Buffers 63
12.4.2 IP Fragmentation 63
12.4.3 Performance 63
12.5 UDP Example Script {UDP_transfer.sc} 64
12.6 TCP Example Script {TCP_transfer.sc} 66
12.7 TCP Send Function Script {TCP_send.sc} 68
12.8 Host Name Resolution 69
12.9 IP Status Flags and Bytes 69
12.10 Advanced Technical Details 69
12.10.1 Time-to-Live (TTL) 69
12.10.2 DNS Name Caching Period 70
13 Simple Telematics Solution with Embedded Applications 71
13.1 System Overview 71
13.2 TCS Script Flowchart 72
13.3 TCS IFL Support 73
13.4 Telematics Core Service Script {TCS_SMS.sc} 74

1 Introduction

The Sony Ericsson M2*m*power package provides a powerful support environment designed to facilitate the development of cost-effective wireless machine-to-machine or man-to-machine (M2M) applications. M2*m*power enables you to develop innovative new applications and embed them directly onto Sony Ericsson's M2M products using specifically designed development tools. Products for use with M2*m*power include the GR47/GR48 radio devices and the GT47/GT48 control terminals.

The M2*m*power package includes a radio device and a range of software and hardware development tools. The script language is based on ANSI C. The software development tools include application function libraries and reference applications, whilst the package also includes the hardware elements required to become operational. In addition, users of the M2*m*power package benefit from comprehensive training and support from Sony Ericsson.

Note : Except where specifically stated, the term radio device in this guide refers to any one of the Sony Ericsson products capable of being programmed with embedded applications using M2*m*power.

1.1 Purpose of Guide

The purpose of the guide is to explain the key components that make up the M2*m*power package and to help users develop their own M2M embedded application to run on Sony Ericsson products.

The guide is intended to support, though not to replace, the detailed training that is available with the M2*m*power package.

The Guide covers the following topics.

- **Software Features** - a detailed description of the M2*m*power Integrated Development Environment (IDE) and the script interpreter.
- **Support** - a list of the extensive support that is available for M2*m*power package users.
- **Intrinsic Function Library**
- **Application Notes** - examples of how to utilize the M2*m*power package to create effective systems applications.

1.2 Who Should Read This Guide?

This guide is aimed at manufacturers, system integrators, applications developers and developers of wireless communication equipment.

1.3 Prerequisites

It is assumed that the person using the M2*m*power package has a basic understanding of the following:

- GSM networking
- Wireless communication and antennas (aerials)
- AT Commands
- RS232
- Micro controllers and programming
- Electronic hardware design

1.4 Related Documentation

- Integrator's Manual.
- AT Commands Manual.

These documents are included on the CD-ROM supplied with the Developer's Kit.

1.5 *Abbreviations and Definitions*

Abbreviation	Explanations
AFE	Administrative Front End
AFMS	Audio from Mobile Station
API	Application programmers interface
AT	Command set based on original Hayes standard use to configure modems. Now extended for GSM and radio device specific configuration
ATMS	Audio to Mobile Station
CBM	Cell Broadcast Message
CBS	Cell Broadcast Service
CSD	Circuit Switched Data
DCE	Data Circuit Terminating Equipment
DTE	Data Terminal Equipment
DTMF	Dual Tone Multi Frequency
EA	Embedded Application
EA Core	Controlling portion of application that is controlled with signaling software
EA Customisable	Application specific script for defining the actions to be taken by the EA Core
EFR	Enhanced Full Rate
EMC	Electro-Magnetic Compatibility
ETSI	European Telecommunication Standards Institute
FR	Full Rate
GDFS	Global Data File System
GPRS	General Packet Radio Service
GPS	Global Positioning System
GSM	Global System for Mobile Communication
HR	Half Rate
HSCSD	High Speed Circuit Switched Data

I2C	Inter IC bus
I/O	Input/output
IDE	Integrated Development Environment
IFL	Intrinsic Function Library
IP	Internet Protocol
ITU-T	International Telecommunication Union - Telecommunications Standardization Sector
ME	Mobile Equipment
MMCX	Micro Miniature Coax
MO	Mobile Originated
MS	Mobile Station
MT	Mobile Terminated
NVM	Non Volatile Memory
OTA	Over The Air
PCM	Pulse Code Modulation
PDU	Protocol Data Unit
RF	Radio Frequency
RFU	Reserved for Future Use
RLP	Radio Link Protocol
RS232	Serial interface standard
RTC	Real Time Clock
RTOS	Real time operating system
SDP	Service Discovery Protocol
Signaling software	Standard run-time GSM software for the radio device
SIM	Subscriber Identity Module
SMS	Short Message Service
SPI	Serial Peripheral Interface
TA	Type Approval
TCM	Telematics Core Module
TCP	Transport Control Protocol

TCS	Telematics Core Service
UART	Universal Asynchronous Receiver Transmitter
UDP	User Datagram Protocol

2 Software Features

2.1 M2mpower Integrated Development Environment

Sony Ericsson's M2*m*power Integrated Development Environment IDE is a powerful software tool that allows you to develop, test and download scripts to your radio device.

2.2 PC Specification

You will need a machine that meets the following minimum specification to run the IDE software and transfer scripts to the radio device.

- Pentium II MMX
- 10MBytes Free disk space
- Microsoft Windows® 98 (SE), 2000, XP or NT

2.3 Overview

The radio device has an embedded controller process. This allows the developer to write C-style "scripts" that determine the behavior of the system, and download them into the radio device. The radio device can then monitor system events by means of its I/O pins, UART, I2C bus or other interfaces, and internally request GSM functionality. The controller is embedded within the radio device's own microprocessor, making the application script run alongside the GSM software. Alternatively, the radio device can still be used as an externally controlled modem.

2.4 The IDE Software

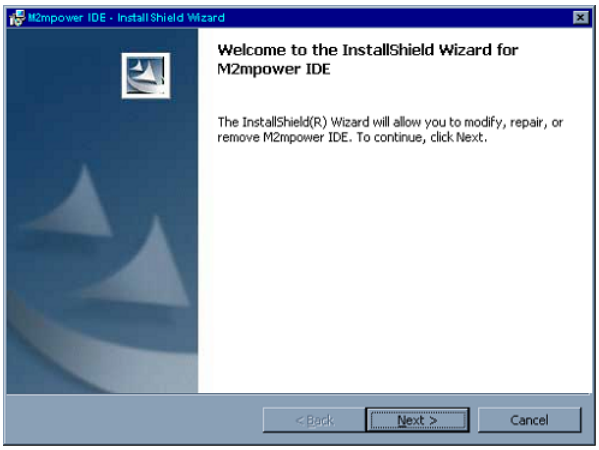
2.4.1 Installing the IDE Software

Insert the M2*m*power CD-ROM into your CD drive.

You will see 2 files:

- M2*m*power IDE (MDI).exe
- M2*m*power Application Guide R1A.pdf
- Select and run M2*m*power IDE (MDI).exe

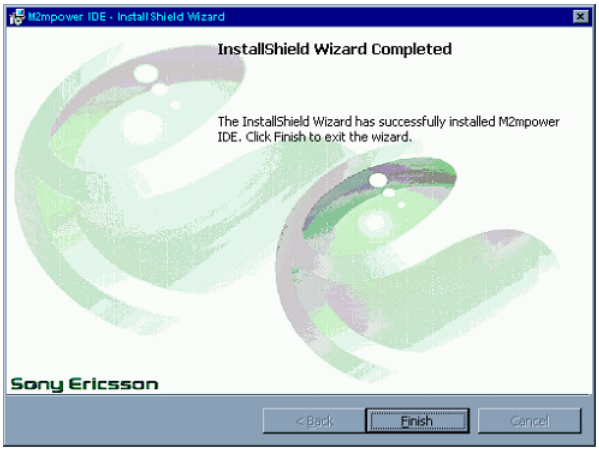
After a few seconds the Sony Ericsson splash screen will be displayed.


M2mpower IDE - Install Shield Wizard
Welcome to the InstallShield Wizard for M2mpower IDE
The InstallShield(R) Wizard will allow you to modify, repair, or remove M2mpower IDE. To continue, click Next.
< Back
Next >
Cancel

If the CD-ROM does not auto-run, select **Start** → **Run** and type D:\M2*m*power IDE (MDI).exe into the **Run** dialogue. (Where D: is your CD drive.)

The Install Shield Wizard for Sony Ericsson IDE software opens, follow the instructions on screen.

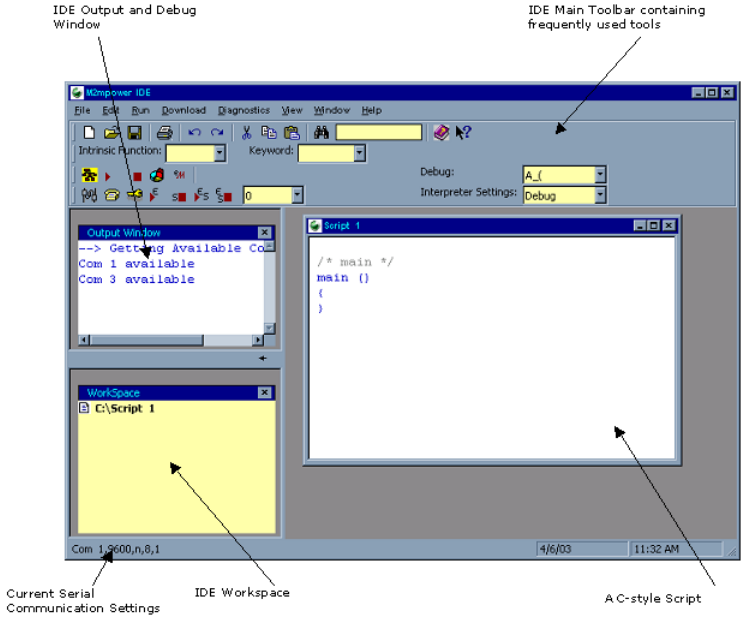
When installation is complete a successful installation dialogue is displayed.


M2mpower IDE - InstallShield Wizard
InstallShield Wizard Completed
The InstallShield Wizard has successfully installed M2mpower IDE. Click Finish to exit the wizard.
Sony Ericsson
< Back
Finish
Cancel

Click **Finish** to close the dialogue and exit the Install Shield Wizard.

2.4.2 Getting Started with IDE

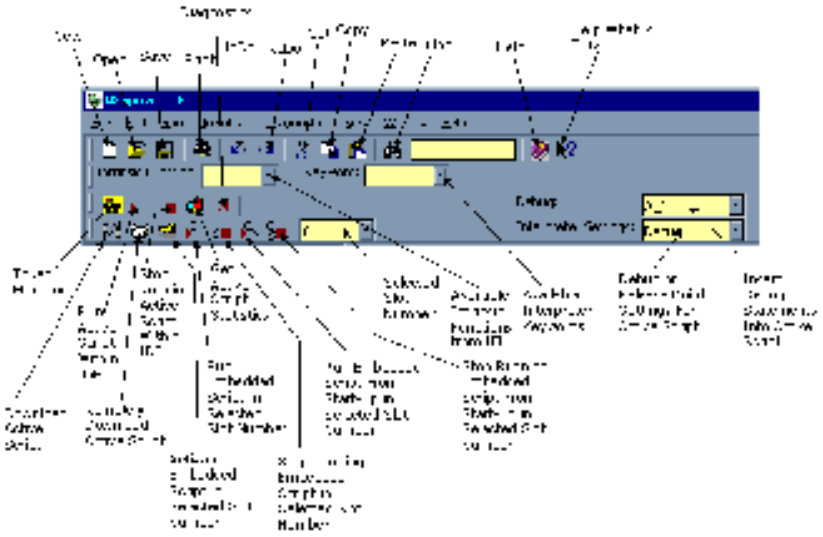
To launch the Sony Ericsson M2*m*power IDE software, click **Start** ➔ **Programs** ➔ **Sony Ericsson M2M Com** ➔ **M2*m*power IDE (MDI)** ➔ **M2*m*power IDE (MDI)**. The IDE software workspace opens.



The M2*m*power IDE provides a system integrator/developer with a development environment for writing, debugging and downloading “C-style” scripts for embedded applications support.

2.4.3 Using the IDE software

Important features of the IDE such as downloading and running scripts can be accessed via the main toolbar.



2.4.3.1 To Interpret a Script

The IDE allows a developer to interpret the active script locally with the IDE. The commands to achieve this are shown in the above diagram. Any results from running a script locally are shown in the Output Window of the IDE.

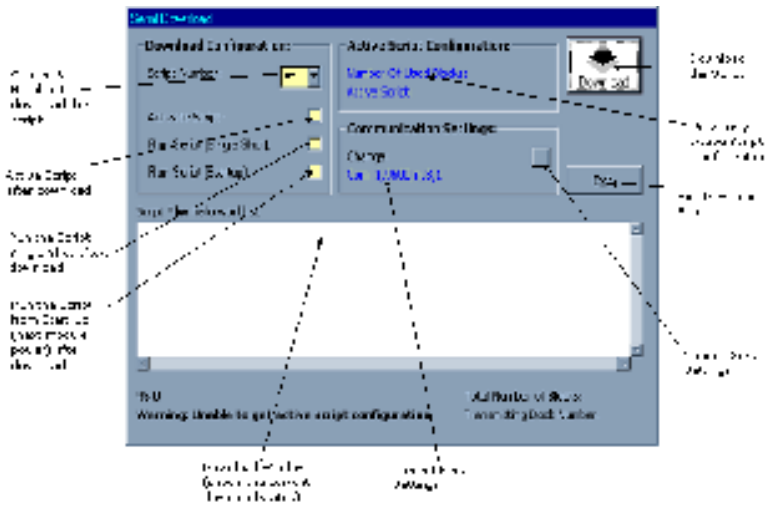
2.4.3.2 To Download a Script

The IDE supports two methods of downloading scripts to an embedded system. Both mechanisms use AT Commands to download scripts. The two methods of downloading scripts are:

- **Serial Download**
- **Remote Download (OTA)**

2.4.3.3 Serial Download

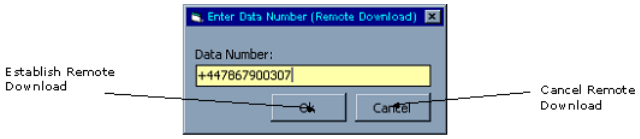
The developer must connect the PC running the IDE to the radio device using a serial connection. All the necessary hardware is contained in the appropriate Developer's Kit. Press to open the Serial Download dialogue box. Use the dialogue to specify your required download settings.



2.4.3.4 *Remote Download (OTA)*

The PC running the IDE can use a modem to set-up a data call to download a script to a radio device. The data phone number of the SIM associated with the radio device is required by the IDE when performing remote downloads. The radio device also requires a script to be running that allows remote control and auto answering functionality. An example of setting up remote control for remote download is available from the M2*m*power IDE Online Help, Intrinsic Function Library (IFL).

Press to open the Enter Data Number dialogue.



When the remote download connection is established the dialogue box shown above for serial download is displayed with minor differences, namely:

1. The script slot number is automatically set to the non activated slot.
2. The script activation settings are fixed to activate the downloaded script and set to run from next restart.
3. Once the download is completed and exit pressed, the embedded application system resets itself and runs the newly downloaded script.

2.4.3.5 To Perform Remote Diagnostic Tests

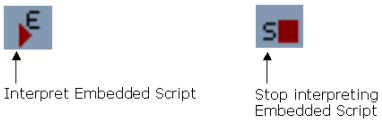
The IDE allows the developer to perform remote diagnostic tests by sending AT Commands via data calls (OTA) to an embedded system. This procedure

is very similar to that of performing remote download. Once the remote connection has been established, the IDE presents the developer with a simple text box in which to enter AT Commands. The responses from these AT Commands are shown in another text box.

2.4.3.6 To Activate a Script

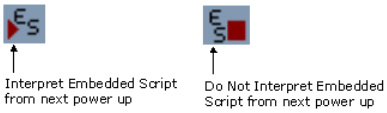
The IDE allows the developer to activate a script from a chosen slot number. This is achieved using a serial communications link between the PC running the IDE and the radio device.

2.4.3.7 To Interpret an Embedded Script



The IDE allows the developer to start the interpretation of a previously downloaded script from a chosen slot number. Similarly the IDE allows the developer to stop interpreting a running embedded script. Both actions are achieved using a serial communications link between the PC running the IDE and the radio device.

2.4.3.8 To Interpret an Embedded Script from Start Up



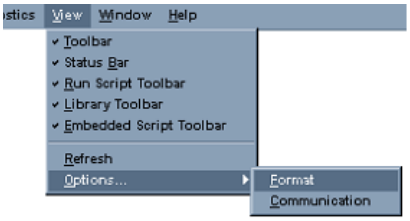
The IDE allows the developer to enable the interpretation of a previously downloaded script (in a specified slot) to start from next power up. Similarly, the developer can disable the interpretation of an embedded script on power up. Both actions are achieved using a serial communications link between the PC running the IDE and the radio device.

2.5 Library Toolbar

The library toolbar references all available intrinsic functions from the Intrinsic Function Library and all interpreter language keywords.

2.5.1 M2mpower IDE

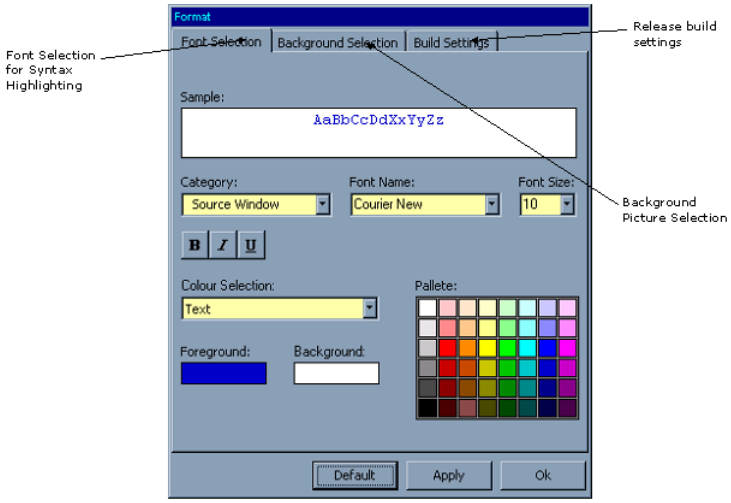
2.5.1.1 Options



The M2*m*power IDE has two options that are accessible from the IDE menu bar as shown above.

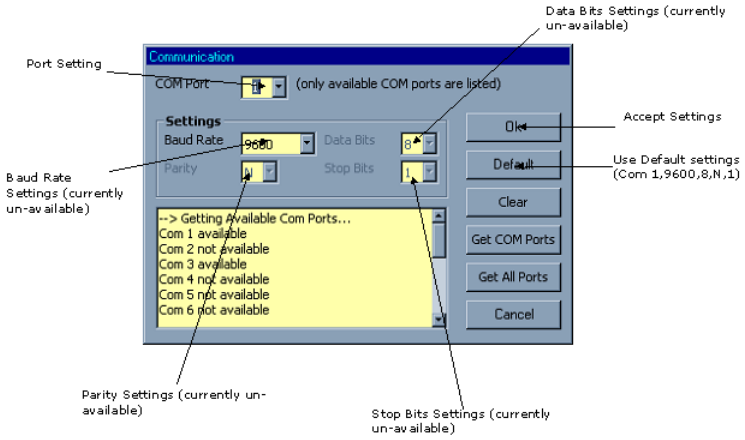
2.5.1.2 Format

This allows the developer to customize the IDE. When Format is selected from the Options menu the following dialogue is opened.



2.5.1.3 Communication Ports Set Up

Allows the developer to modify/ change the current serial communications settings when interfacing with an embedded system. Select Communication for the Options menu to display the following dialogue.


Data Bits Settings (currently un-available)
Port Setting
Communication
COM Port
(only available COM ports are listed)
Settings
Baud Rate
9600
Data Bits
8
Parity
Stop Bits
1
Ok
Accept Settings
Default
Use Default settings (Com 1,9600,8,N,1)
Clear
Get COM Ports
Get All Ports
Cancel
Baud Rate Settings (currently un-available)
--> Getting Available Com Ports...
Com 1 available
Com 2 not available
Com 3 available
Com 4 not available
Com 5 not available
Com 6 not available
Parity Settings (currently un-available)
Stop Bits Settings (currently un-available)

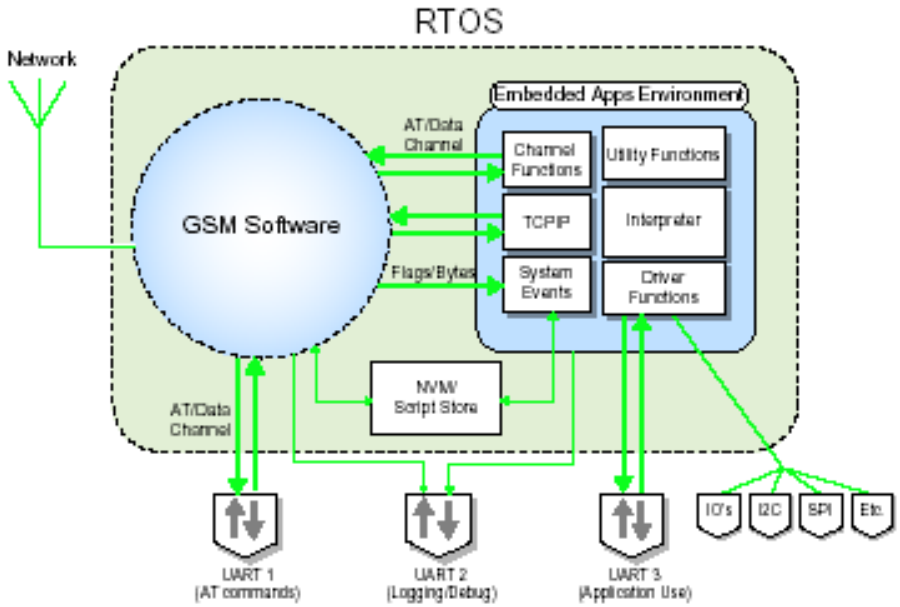
3 How is the script embedded?

3.1 Environment

The controller process sits in the radio device, running within the Real-Time Operating System that also handles the GSM software processes. The controller process works in the background, so as not to disturb the GSM functionality in the radio device.

The controller process uses an interpreter; see “Script Interpreter”, page 18 for more details: The Interpreter reads the script from the NVM area of the radio device’s
required functi

The diagram b
system, and th
software and t
System in whic



There are two main interfaces:

The “Channel” interface to the GSM software – through which AT commands and data can be sent in a similar manner to using UART1. It can be seen as an internal AT command port. Functions that use the Channel interface to send SMS’s and other higher level commands are called “Level 2” and “Level 3” intrinsic functions in the IDE online help.

The “Drivers” interface to the low level functions. These “drivers” consist of sets of functions which allow the control of the radio device’s interfaces. The IDE online help refers to these as “Level 1” intrinsic functions. Interfaces available include UART, I2C, NVM, SPI, GPIO, ADCs, DAC, TCP/IP (over GPRS).

“Driver” functions offer direct use of hardware and software functions and are efficient and fast – generally the lowest level at which you can talk to the radio device with a script. “Channel” functions, are at a higher level of abstraction and will take longer to execute.

System events and status are communicated to the script via a set of flags and bytes. These are set when events occur or the system status changes. The flags need to be polled by the script in order for the script to react to system events. An example of a system event is SMS RECEIVED. This is a “trigger” event which is cleared once the flag is read. INCOMING CALL is a “state” event which reflects the current status of the radio device. An example of a system status byte is NETWORK STATUS, which indicates several types of status e.g. “not connected”, “roaming”.

3.2 Limitations

Operations can have significant latency times. The GSM software is higher priority than the Application, and so any GSM operation takes precedence. In times of heavy data activity, the Application may be “switched out” for a period. If GSM activity is not required, consistent response times can be obtained by using the Controller Mode functionality.

The scripting language does not support interrupts. Therefore a script should poll the flags as required.

4 Script Interpreter

4.1 Overview of the Script Interpreter

The script interpreter transfers a script produced in the IDE to the radio device. The script interpreter parses the script written in “C” as it is transferred to the radio device.

The radio device can hold two scripts at any one time, but only one script can be active.

The script is downloaded to the module using the IDE. When the script is activated and set to run, the interpreter initializes the available resources, translates and loads the script from the NVM into RAM, and then parses the script line by line. Intrinsic function calls in the script are mapped to the functions available in the module and executed appropriately. The interpreter runs within the radio device as part of the RTOS as a background level process, so as not to affect the GSM operation of the device.

4.2 Interpreter Language

The interpreter works as a line based interpreter (similar to BASIC). Syntax is a limited version of that of C. It allows iterations (while, for), conditional statements (if. else), functions, pointers, comments, arrays, string literals, assignment and arithmetic, logical and bitwise operators. It supports two data types: int (32bit) and char (8bit).

Channel and driver functions are available from the Intrinsic Function Library (IFL). All radio device specific functions have to be accessed by the IFL. The IDE online help explains the syntax of each function and details its use.

4.3 Limitations

No floating point arithmetic.

No switch statements.

No typecasting – type checking needs to be done manually to avoid errors.

No “const” or “static” keywords.

Function return type is “int” – not explicitly specified in declaration.

No C++ “\\” style comments – only “/* */” C-style comments.

4.4 5 Steps to Application Production

4.4.1 Writing a script

The script needs to be written in a text editor such as that provided in the IDE. The script must have a main() function, for example:

```
int val;
main()
{
    prtf("\n Start Script!");
    val = io(0,0,0); /* read IO1 */
    prtf("\n IO1 =%d", val);
    prtf("\n End Script!");
}
```

4.4.1.1 Preliminary debug

The script can be tested in the IDE for a range of errors, including syntax errors. Functional behavior cannot be tested at this stage.

4.4.1.2 Downloading a script

The script downloaded mechanism as supported by IDE uses two AT commands – AT*E2APC and AT*E2APD. The download is initiated by sending the AT*E2APD command with some script information. The radio device responds, and the script is downloaded using the Xmodem protocol. For AT Commands details see the AT Commands Manual. Once downloaded, the script is validated and if successful it can be activated. It can be run from power up by using AT Commands or via the IDE.

4.4.1.3 Debugging a script on the radio device

Once in the radio device, the script can be debugged using print statements. The print function allows debug information to be output along with the GSM logging information on UART2. The GSM logging information can be turned off to allow easier reading of the debug data. If there is a memory error or interpreter error when parsing the script, an appropriate error message will be displayed in the logging information. Error messages are of the from ERROR#xx: LINExx: <DESCRIPTION>.

4.4.1.4 Script Manipulation and run control

There is the capability for 2 scripts to be stored within the radio device. Only one script can be active at a time. Only the active script can be started. When a script is downloaded, the destination slot (0 or 1) is determined.

Once downloaded, the relevant script slot can be activated. It can then be run if the other script is not already running.

It is possible to set a script to be run from start up of the radio device. This option, when selected, will cause the last active script to be run when the radio device starts up. The reason for having two script slots is that one can be running while another is downloaded. If the newly downloaded script is activated, then when the radio device is subsequently reset it will cause the new script to start running, provided that the new script had been set to run from start up. This functionality is crucial for OTA script download.

Following the issue of a stop signal, when the interpreter next has control it will stop the execution of the script and clean up. If the script is executing a function that takes a long time to return (e.g. TCP connection or a long delay), the response to the stop command may be an error due to time-out. The application will stop as long as control is eventually returned to the interpreter.

4.5 Script Memory Storage

Maximum script size is 350 blocks of 128 bytes (44800 bytes). This space is shared between the scripts if 2 are present.

The interpreter has 50000 bytes of RAM available to it – this includes dynamic stack space (fixed size of 20400 bytes), global variable storage, and all other RAM use. If this size is exceeded an error will occur when trying to execute on the radio device, as a larger size of memory will not be possible to allocate. Script memory sizes can be obtained via the IDE.

Since scripts are stored in the form they are written, the size of the script can be reduced by using short variable and function names, reducing the number of print statements and removing comments.

5 Support

IDE and interpreter upgrades will be made available via the extranet solution.

To get access please contact your salesperson.

The M2*m*power package provides access to comprehensive group or one to one training. The training is aimed at Engineers who are already conversant in ‘C’. The training comprises the implementation of the application to be embedded onto the radio device, and includes support during the development phase. Ongoing support will also be available after the implementation phase.

The key outcomes of the course will be:-

- To understand the concept of embedded applications and their use on the radio device.
- To become conversant with the IDE.
- To be able to write, debug and download embedded applications onto the radio device.
- To manage TCP/IP communications using an embedded application.

Web based support will provide FAQ's, Technical Description, Training package, Integrator’s Manual and AT Commands Manual.

Ongoing Product to System level support will be provided throughout the product lifecycle.

6 Intrinsic Function Library

The Intrinsic Function Library (IFL) contains a set of built-in functions that are accessible from a script. The M2*m*power IFL contains the following functions, grouped into categories.

6.1 Level 1 Functions

Debug Library

prtf	Print formatted output to the standard output stream.

Utility Library

itoa	Convert an integer to a string.
atoi	Convert string to integer.

String Library

scat	Append a string.
scmp	Compare strings.
scpy	Copy a string.
slen	Get the length of a string.
sstr	Find a substring.
sncpy	Copy characters of one string to another.

Memory Manipulation Library

mset	memset, set a buffer in memory to a specified value
mcpy	memcpy, copy a number of bytes from one buffer to another
mmve	memmove, move a number of bytes from one buffer to another
mcmp	memcmp, compare two buffers to each other

General Hardware Library

rc	Remote Control, using a channel set up in a data call.
rst	Resets the module, performing an IMSI detach if necessary.
puct	Configures an IO pin as a pulse counter/reads that pulse counter.
io	Handles the modules IO pins, allowing configuration, setting levels, and reading values.
spc	Switches io's used internally by GSM software for general use and vice versa.
wd	sets and kicks the script watchdog facility

Module Utility Library

dlyms	Delay 50 milli-second intervals.
dlys	Delay 1 second intervals.
prs	Switches on/off modules GSM software log data. Used to make script debug prints more visible.
pin	Allows entry, re-enable, disable of the SIM PIN (CHV1).

System Status Library

tm	Returns number of system ticks since power on.

gtf	Gets the value (TRUE or FALSE) of a specified system status flag.
gtb	Gets the byte value (0x00 - 0xFF) of a specified system status byte.
Clip	Gets the CLIP (Calling Line Identifier) text to the users buffer.

Channel Library

chcrt	Create a channel.
chdst	Destroy a channel.
chsts	Get a channel status.
chw	Write data to a channel.
chr	Read from a channel.

M-Bus Driver Library

mxc	Configure the MAX3100 interface (for MBUS).
mxs	Send data to the MAX3100 device, to be output as UART data.
mxr	Read data from the MAX3100 device, input from external uart (MBUS) data.

SPI Driver Library

spic	Configure the SPI bus implementation on the IO pins.
spis	Send data over the SPI bus implementation on the IO pins.

I2C Driver Library

i2c	Configure the i2c interface (Change speed).
i2r	Read data from the i2c interface.
i2w	Write data to the i2c interface.

UART Driver Library

utc	Configure the UART3 interface (Open/Close/Set Baudrate).
utr	Read data from the UART3 interface.
uts	Send data to the UART3 interface.
utrl	Return number of bytes buffered on Receive.
utsl	Return number of bytes buffered on Transmit.

Non-volatile Memory (NVM) Library

nvm	Write/ Read from Non-Volatile Memory (NVM).

Database Library

dbadm	Database admin functions (Restore, Create, Destroy).
dbadd	Add record to database instance.
dbget	Retrieve record from database.
dbghd	Get record header.
dbshd	Set record header.
dbfnd	Find record.
dbdel	Delete record.
dbinx	Index database record.

IP Library

pdpa	Activate a PDP context for IP use
ipo	Open an IP socket (TCP or UDP)
ipc	Close an IP socket

ipi	Return current IP information (e.g. IP Address)
iprh	Resolve Host address to IP address
udps	Send Data via UDP
udpr	Receive Data via UDP
tcpc	Make a TCP connection
tcps	Send Data via a TCP connection
tcpr	Receive Data via a TCP connection

Keypad Control Library

kyc	Keypad Configure
kyd	Keypad Delete
kyr	Keypad Read

Checksum Library

ccrc	Calculate CRC

6.2 Level 2 Functions

AT Command Library

atcrt	Create an AT command channel.
atdst	Destroy an AT command channel.
atsnd	Send AT command get response.

6.3 Level 3 Functions

Short Message Service (SMS) Library

smsi	Initiailise Short Message Service (SMS).
smssc	Set Short Message Service (SMS) Service Centre.
smss	Send Short Message Service (SMS) Message.
smsd	Delete Short Message Service (SMS) Message.
smsrs	Find first Un-read Short Message Service (SMS) Message from memory.
smsrm	Read Short Message Service (SMS) Message Data.
smsra	Read Short Message Service (SMS) Message Address.
smsrd	Read Short Message Service (SMS) Message Time and Date Stamp.

Phonebook (PB) Library

pbi	Phone Book Initialise.
pbrtn	Phone Book read number type.
pbrn	Phone Book read number.
pbra	Phone Book read alphanumeric tag.

Global Positioning Satellite (GPS) Library

sirfc	Creates/ Configures UART 3 to send/ receive SiRF Binary/ NMEA Messages.
sirfd	Destroys/ Closes UART 3 from sending/ receiving SiRF Binary/ NMEA Messages.
sbs	Send a SiRF Binary message to a GPS device.
sbfm	Filter a SiRF Binary Message from a GPS.
snsp	Set GPS device protocol and communication parameters.

snni	Initialise GPS device for a warm start providing position, clock offset and time.
sndgpsp	Set serial port B of GPS device to receive RTCM differential corrections.
snqc	Control the output of standard NMEA messages.
snllani	Initialise GPS device for a warm start providing latitude, longitude, altitude, clock offset and time.
sndev	Enable/ Disable development data from GPS device.

7 Application examples

The example applications in this section have been written primarily for the GR47/GR48 radio devices. The controller mode, TCP/IP and Simple Telematics applications are also relevant to the GT47/GT48 control terminals.

Throughout the example applications, any specific radio device signal names used refer to GR47/GR48 signals.

Where script examples are given, the name of the corresponding IDE compatible file is given in brackets. These files can be found on the M2*m*power CD-ROM.

8 Controller Mode

8.1 Introduction

The radio device, when powered up normally, will start up the GSM signaling software and look to register with a GSM network. The Embedded Application script runs as a background process, as and when the GSM software is idle. Controller Mode is a mode of operation whereby the radio device powers up with a minimal subset of functionality. The GSM signaling software is halted, and the Embedded Applications script will effectively have “control” of the processor.

Controller Mode allows an application to run with more predictable response times. If the GSM functionality is not required for a long period of time, but some periodic monitoring of IO’s is required, Controller Mode can be used, giving faster response, lower latency and a more predictable execution time during Controller Mode, causing the current drawn to maintain a consistent low level without network dependent fluctuations.

8.2 Technical Description of Controller Mode

The radio device’s mode of operation can only be changed on power up. Thus, to change the radio device between Normal and Controller Modes, the radio device is reset. The Embedded Application needs to call the Reset function (rst()) specifying the mode to reset into – either Normal or Control Mode. The radio device will then reset into that mode.

When the radio device is reset into Controller Mode:

The radio device performs a software reset, jumping back to the software start vector and beginning as from a standard power up.

The radio device detects a pattern in flash to indicate that Controller Mode is required on this power up. Software then initializes only the hardware blocks that are required for Controller Mode.

The OS initializes and all the processes are initiated. All GSM software processes and interrupts are disabled, apart from those servicing the watchdog and essential timer features.

The radio device synchronizes the 13MHz clock to the RTC clock before switching off the radio circuits and regulators and starting the Embedded Application.

The script must be setup so that it is run from startup and checks the status of the mode using a system status flag. This will allow the script to switch between functionality that works in Controller Mode, and functionality that is run in Normal mode.

8.2.1 Limitations – restricted functionality

The operations in Controller Mode are limited to those using the low level hardware interfaces and simple utility functions. The functions that can be called in Controller Mode are restricted, due to the fact that the GSM software is non-operational. A list of the IFL functions and their support in Controller Mode is given below. For IFL Name Descriptions refer to Appendix A.

IFL Name	*CM*	*IFL Name*	*CM*	*IFL Name*	*CM*	*IFL Name*	*CM*	*IFL Name*	*CM*
Atcrt	FALSE	Dlyms	TRUE	Mset	TRUE	Scat	TRUE	Snqc	FALSE
Atdst	FALSE	Dlys	TRUE	Mxc	TRUE	Scmp	TRUE	Snsp	FALSE
Atoi	TRUE	Gtb	TRUE	Mxr	TRUE	Scpy	TRUE	Spc	TRUE
Atsnd	FALSE	Gtf	TRUE	Mxs	TRUE	Sirfc	FALSE	Spic	TRUE
Ccrc	TRUE	i2c	TRUE	Nvm	TRUE	Sirfd	FALSE	Spis	TRUE
Chcrt	FALSE	i2r	TRUE	Pbi	FALSE	Slen	TRUE	Sstr	TRUE
Chdst	FALSE	i2w	TRUE	Pbra	FALSE	Smsd	FALSE	Tcpc	FALSE
Chr	FALSE	Io	TRUE	Pbrn	FALSE	Smsi	FALSE	Tcpr	FALSE
Chsts	FALSE	Ipc	FALSE	Pbrtn	FALSE	Smsra	FALSE	Tcps	FALSE
Chw	FALSE	Ipi	FALSE	Pdpa	FALSE	Smsrd	FALSE	Tm	TRUE
Clip	FALSE	Ipo	FALSE	Pin	FALSE	Smsrm	FALSE	Udpr	FALSE
Dbadd	TRUE	Iprh	FALSE	Prs	TRUE	Smsrs	FALSE	Udps	FALSE
Dbadm	TRUE	Itoa	TRUE	Prtf	TRUE	Smss	FALSE	Utc	TRUE
Dbdel	TRUE	Kyc	TRUE	Puct	TRUE	Smssc	FALSE	Utr	TRUE
Dbfnd	TRUE	Kyd	TRUE	Puts	TRUE	Sncpy	TRUE	Utrl	TRUE
Dbget	TRUE	Kyr	TRUE	Rc	FALSE	Sndev	FALSE	Uts	TRUE
Dbghd	TRUE	Mcmp	TRUE	Rst	TRUE	Sndgpsp	FALSE	Utsl	TRUE

Dbinx	TRUE	Mmve	TRUE	Sbfm	FALSE	Snllani	FALSE	Wd	TRUE
Dbshd	TRUE	Mmve	TRUE	Sbs	FALSE	Snni	FALSE		

8.3 Controller Mode Example

As a case study, we have an application with the following behaviour:

A system communicates its status by sending a short (16 byte) packet of data via a serial (RS232) link. This data required to be sent to a host once a day in order to maintain a central database with details of the system status.

The status packets begin with a byte ‘S’ and end with the byte ‘E’.

Structure of the solution

The radio device could be integrated into the system, connecting UART 3 to the system’s serial link. The Embedded Application would then read the status packets in, and batch send them off to the host in an SMS message.

The application is mainly run in Controller Mode, as no GSM activity is required until the SMS is sent. Once a set number of packets has been reviewed, or a day has passed (whichever the sooner), the radio device will then switch back to Normal Mode and send the SMS with the status report. The radio device then resets to Controller Mode and listens for more status packets.

(If there is a requirement for a stringent timing on receiving the status reports, Controller Mode will be necessary in order to give reliable response time.)

The Application Listing is given at the end of this note. The Application makes use of a database functionality to store the status reports while in Controller Mode, so that they can be read and placed into a SMS message for sending in Normal Mode. Refer to the IDE online help for detailed descriptions of each of the IFL functions used in this script.

The application script consists of 3 functions:

- **Main()** - called on start-up and determines which mode function is called.
- **DoControl ()** - Initializes the database, UART and buffers. Waits for a packet of data, and once it has been received checks the start and stop bytes to make sure it is valid report. If so, the report is stored in the database, and a count is incremented. Once the count reaches 10, or a day has passed since an update was last sent, the radio device resets into Normal Mode to send the status update.
- **DoGSM()** - Restore the database, and reads out each new record, storing them in the SMS string, before deleting the record. Once all the records have been transferred, the SMS is sent. The radio device then resets into Controller Mode and awaits further data.

8.3.1 Running the Example Script

In order to run this example script:

1. Connect the UART3 Tx and Rx lines via an RS232 level shifter to a COM Port on your PC; you can use the Demo Board for this.
2. Put the script into the Editor, and replace the SMS_NUMBER field with a valid mobile number you want the SMS reports to be sent to.
3. Download the script, making sure to check the “Run Script on Startup” box. This will enable the application to run on every startup – crucial for the functionality with Controller Mode.
4. Run the script. (You can see the debug outputs if you monitor the UART2 port (115200 baud, 8 data bits, no parity) and set the service pin HIGH.)

The radio device will have reset into Controller Mode and be waiting for data. To enter data, use a terminal package and send packets of the form “SxxxxxxxxxxxxxE” where x is any 7-bit ASCII value. Once 10 valid packets have been received, or a day has passed, the radio device will reset and send the data in an SMS to the number you have entered.

8.4 Controller Mode Script {Controller_Mode.sc}

```
int CONTROLLER_MODE = 11;
int REG_STATUS = 10;
int REGISTERED = 1;
char START_BYTE = 'S';
char STOP_BYTE = 'E';
int CONTROLTIME = 18748800; /* 1 day - time in ticks 217 a second *60*60*24 */
int DATA_PKT_SIZE = 15;
int RECORD_THRESHOLD = 10;
char SMS_NUMBER[13] = “012345678901”;  /*replace this with a valid Mobile Phone number*/
int SMSBUFSIZE = (DATA_PKT_SIZE*RECORD_THRESHOLD)+1;
char NEW_FLAG = 0x01;
char Buf[DATA_PKT_SIZE+1];
int db_id = 1;
/*Carry out Controller Mode tasks */
DoControl()
{
        int Count = 0;
        int recid = 0;
        int StartTime = tm();
        int TimeExceeded;
        mset(Buf,0,DATA_PKT_SIZE+1);
        /*restore and open db*/
        dbadm(1);
        /*destroy all db instances*/
        dbadm(2);
        /*Create db - db_id should always be 1*/
        db_id = dbadm(0);
        prtf(“\n New db_id = %d”,db_id);
        /*open UART3, 9600 */
        utc(1,3);
        /*loop looking for incoming packets*/
        while(1)
        {
                /*if at least a packet of data is available*/
                if(utrl() >= DATA_PKT_SIZE)
```

```
                {
                        /*read packet*/
                        utr(Buf,DATA_PKT_SIZE);
                        prtf("\n Read packet %s",Buf);
                        /* verify packet*/
                        if((Buf[0] == START_BYTE) && (Buf[DATA_PKT_SIZE -1] == STOP_BYTE))
                        {
                                /*Add to db - flag as new */
                              if(dbadd(db_id,Buf,DATA_PKT_SIZE,NEW_FLAG,0,0) == 0)
                                {
                                        prtf("\n Error Adding to DB!");
                                }
                                        Count++;
                                        prtf("\n Count = %d",Count);
                        }
                }
                TimeExceeded = (tm() - StartTime) > CONTROLTIME;
                if(TimeExceeded || Count >= RECORD_THRESHOLD)
                {
                        rst(0); /*Start up GSM mode*/
                }
                prtf("\n Waiting for Data!");
                dlys(1); /*poll once a second */
        }
}
/*Carry Out GSM Tasks*/
DoGSM()
{
        char SMS_Buf[SMSBUFSIZE];
        int CurrRec = 0;
        int CurrLen = 0;
        int Len;
        prs(0);
        /*restore and open db*/
        if(dbadm(1) != db_id)
        {
                /*db error - return to Controller Mode!*/
                rst(1);
        }
        mset(SMS_Buf,0,SMSBUFSIZE);
        while(gtb(REG_STATUS) != REGISTERED);
        prtf("\n Registered!");
        /*Send SMS's with IO Data Retrieved*/
        CurrRec = dbfnd(db_id,1,0,NEW_FLAG,0,0);
        while(CurrRec != 0)
        {
                Len = dbget(db_id,CurrRec,SMS_Buf + CurrLen);
                CurrLen = CurrLen + Len;
                if(CurrLen >= SMSBUFSIZE)
                {
                        prtf("\n Too Much Data!");
                        break;
                }
                dbdel(db_id,CurrRec);
                CurrRec = dbfnd(db_id,1,0,NEW_FLAG,0,0);
        }
        if(slen(SMS_Buf) > 0)
                {
                int err;
                atcrt();
                prtf("\n SMS String = %s",SMS_Buf);
                err = smss(SMS_NUMBER,SMS_Buf,129,slen(SMS_NUMBER),SMSBUFSIZE);
                if(err != 0)
                {
                        prtf("\n Failed sending SMS!");
                }
```

```
                atdst();
        }
        rst(1); /* reset in Controller Mode */
}
/*Main Function*/
main()
{
        if(gtf(CONTROLLER_MODE))
        {
                DoControl();
        }
        else
        {
                DoGSM();
        }
}
```

9 Keypad and I2C LCD

9.1 Introduction

Whe
inte nan-
mac

Her the
inte

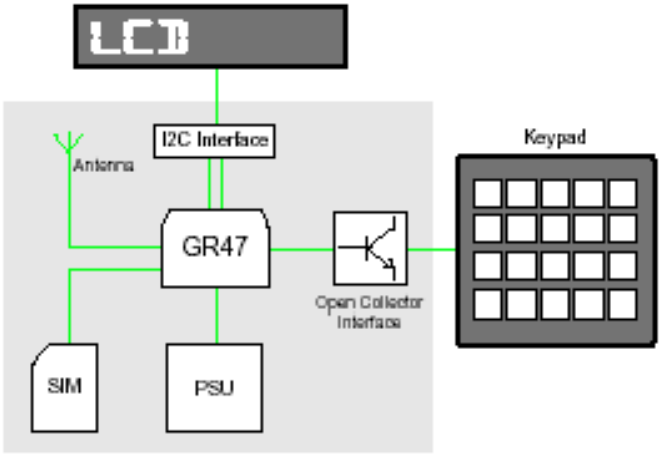


Figure 2.1 Application Block Diagram (Fixed cellular terminal)

9.2 Keypad

9.2.1 Operation

When the script executes it calls a key-scan routine in an endless loop. When no key is pressed the key-scan routine returns the code 0xFF. A key-press is detected when any one of the KeyRow inputs receives a logic low. The key-scan routine identifies which KeyColumn driver was active when the key-press was detected and the routine provides a return code representing the combination of row and column.

9.2.2 Set-up

The keypad driver setup uses the function kyc() to define which rows and columns are activated for the application. This allows the user to select the most suitable keypad size and avoids tying up control I/O which would be more usefully applied elsewhere in the application.

This application example utilizes the full complement of column drivers and row receivers to provide a 20 key interface.

Note: The GND ground connection may be used as a column driver. When used, this is referred to as Column 0.

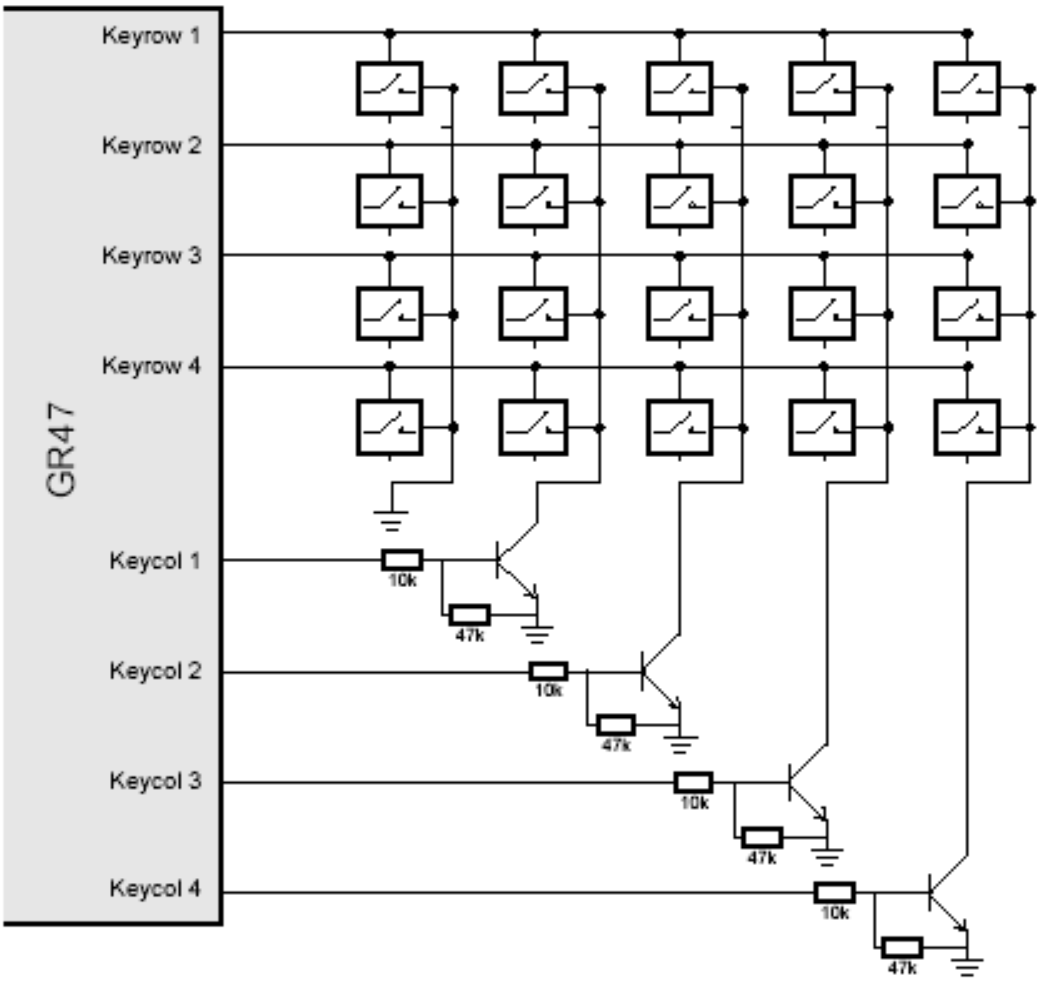


Figure 2.2 Keypad Interface Schematic

kyc - Keypad Configure

Keypad Configure - initialises specified pins for keypad control

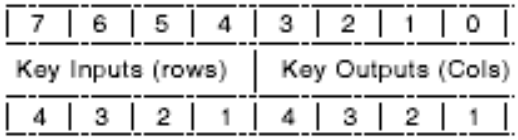
int kyc(char config, char translate);

Return Value:

1 = Success

0 = Failure

Parameters:

Config	A byte mask of the pins required for the KeyPad - byte assigned as  follows: For example, the mask 0x7E (0111 1110) would configure rows (inputs) 1, 2 & 3 and columns (outputs) 2, 3 & 4 (and 0). **Note:** Column 0 does not need a value as it is always available.
Translate	0 - Keyread response will be a byte mask 1 - Keyread response will be an integer between 0 and (# of keys -1)
Remark:	This command initialises the keypad. The pins used for the keypad are **Inputs 1-4** and **Outputs 1-4**. These have to be configured for I/O use using the relevant **io( )** and **spc( )** commands before the **kyc( )** is called, or else the command will return failure. After creation, the **kyr( )** function can be used. **Note:** Column 0 does not require an output pin - it is always configured. This means that he mask 0xF0 is valid as a 4 row 1 Column (Col 0) key pad.

9.2.3 Example

```
main()
{
        int val;
        /*setup All Key pins*/
        spc(RI,0); /* turn off RI */
        spc(DTR,0); /* turn off DTR */
        spc(DCD,0); /* turn off DCD */
        spc(DSR,0); /* turn off DSR */
        spc(CTS,0); /* turn off CTS */
        io(4,KEY_IN2,0); /*switch in I2*/
        io(4,KEY_IN3,0); /*switch in I3*/
        io(4,KEY_IN4,0); /*switch in I4*/
        if(kyc(0xFF,1)) /*maximal keypad, Translate keypress*/
        {
                prtf("keypad configured ok = %x",val);
        }
}
```

Output

keypad configured ok!

kyr - Keypad Read

Keypad Read - returns the current key press as either a byte mask or as an integer.

int kyr();

Return Value

Returns value of key press. If no key is pressed the function returns 0xFF.

Note : If the kyc() function had the translate parameter set to 0, kyr() returns a byte mask showing which row and column are associated with the key press. (Refer to kyc() for the byte mask definition.)

For example, if kyr() returns 0x24 (0010 0100), this decodes as row (input) 2 and column (output) 3.

If the kyc() function had the translate parameter set to 1, kyr() returns a number between 0 and (Maximum number of keys - 1). The keys are numbered from the first row used and the first column used, incrementing along rows and then columns.

For example, if a keypad is configured with mask 0xE7 (1110 0111), then key numbers 0 to 11 would be assigned as follows.

	Col 0	Col 1	Col 2	Col 3	Col 4
Row 1	-	-	-	-	-
Row 2	0	1	2	3	-
Row 3	4	5	6	7	-
Row 4	8	9	10	11	-

Parameters

None

Remarks

kyr() can only be called after a successful **kyc()** call. The Keypad is scanned

Example

```
main()
        {
        int val;
        /*setup All Key pins*/
        spc(RI,0); /* turn off RI */
        spc(DTR,0); /* turn off DTR */
        spc(DCD,0); /* turn off DCD */
        spc(DSR,0); /* turn off DSR */
        spc(CTS,0); /* turn off CTS */
        io(4,KEY_IN2,0); /*switch in I2*/
        io(4,KEY_IN3,0); /*switch in I3*/
        io(4,KEY_IN4,0); /*switch in I4*/
        kyc(0xFF,1); /*maximal keypad, Translate keypress*/
        while(1)
        {
                val = kyr();
                if(val != 0xFF)
                {
                        prtf("key pressed = %x",val);
                }
}
```

Output

Key Pressed = xx /*when key is pressed*/

kyd - Keypad Destroy

KeyPad Destroy - disables keypad and frees up used I/O pins

int kyd();

Return Value:

1 = Success

0 = Failure

Parameters:

None

Remarks

This function is called to free up keypad keys to allow reconfiguring of I/Os. Only valid if the Keypad is active.

Example

```
if(kyc(0xFF,1);) /*configure maximal keypad */
{
...
val = kyr();
...
if(kyd())
{
prtf("keypad destroyed!");
}
}
```

Output

```
..Keypad is configured
..Keypad is read
..Keypad is destroyed
keypad destroyed!
```

9.3 I2C LCD

9.3.1 Operation

The I2C device used is a general purpose IO controller which is connected to a parallel port controlled LCD module.

When the script executes, it writes I2C data to set the GPIO chip outputs. The GPIO outputs are connected to the data and control lines of the LCD module. The high speed of the I2C data output enables us to create a set of up to 8 discrete waveforms which meet the requirements of the LCD electrical interface. The required timings of the LCD interface are provided in the following pages, along with the I2C LCD interface diagrams and pin-out.

The chosen LCD uses either an 8 bit or a 4 bit data interface with 3 additional control signals RS, E, R/W. We choose to operate the LCD in 4 bit mode and so can provide the 7 required signals with a single 8 bit I2C-GPIO converter.

The I2C register has been defined as follows:

BIT	P7	P6	P5	P4	P3	P2	P1	P0
LCD	n/c	E	RS	R/W	D7	D6	D5	D4

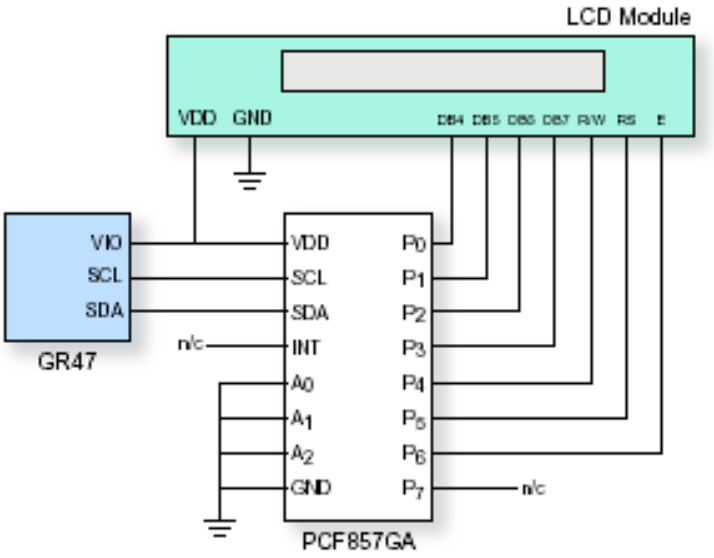
9.3.2 Set-up

The I2C driver uses the function I2C() to set the clock rate for the I2C interface. There are two rates available, 100kHz and 400 kHz.

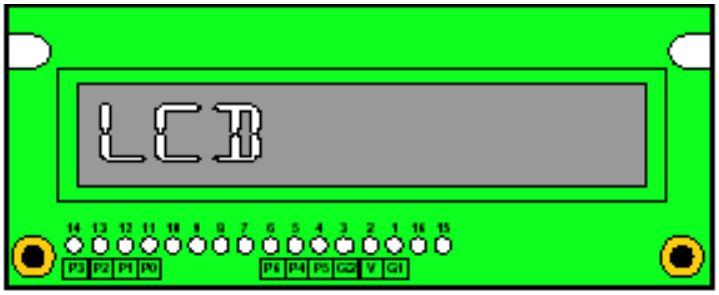
This application example uses the 400kHz rate.

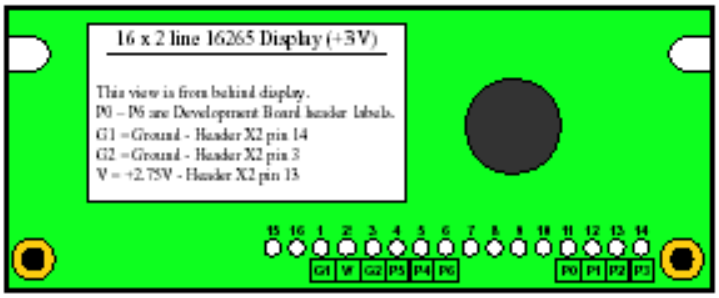
The I2C GPIO interface IC is available from Philips Semiconductor and has manufacturers part number PCT8574A. The address range of the device is 0x70 to 0x7F in hexadecimal notation. For this application we have selected address 0x70 for writing data and 0x71 for reading data.

To write an 8 bit data instruction to the IC2 port we use the command i2w(Addr, NumOfBytes, Data, &Ack).



LCD Interface Schematic




16 x 2 line 16265 Display (+3V)
This view is from behind display.
P0 – P6 are Development Board header labels.
G1 = Ground - Header X2 pin 14
G2 = Ground - Header X2 pin 3
V = +2.75V - Header X2 pin 13

LCD Interface

LCD spec

Supplier	Varitronix Limited (Samsung KS0070B LCD Controller)
Part Number	MDLS16265SSXLV (3 Volt)
Description	16 Characters x 2 Lines

Pinout

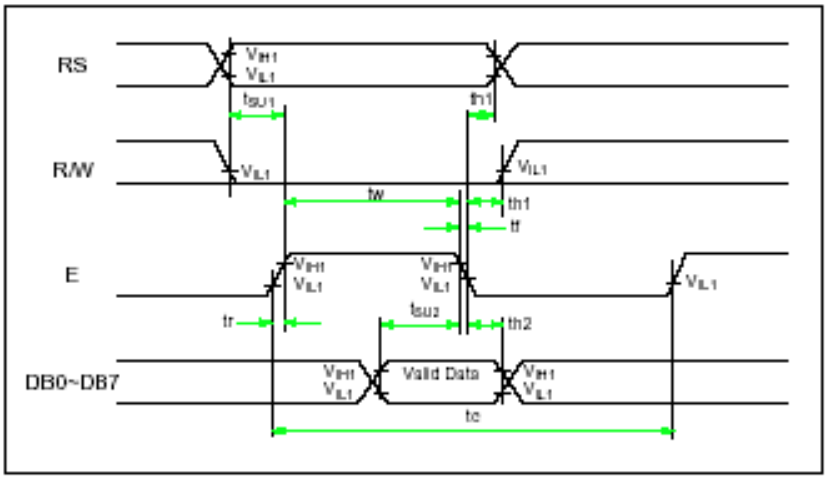
PIN #	NAME	DESCRIPTION
1	VSS	Ground
2	VDD	Logic Supply (2.75V)
3	VO	LCD Supply (0V)
4	RS	Register Select
5	R/W	Read/Write
6	E	Enable
7	DB0	Data0
8	DB1	Data1
9	DB2	Data2
10	DB3	Data3
11	DB4	Data4
12	DB5	Data5
13	DB6	Data6
14	DB7	Data7
15	LED(+)	Backlight Anode
16	LED(-)	Backlight Cathode

LCD AC Timing Characteristics

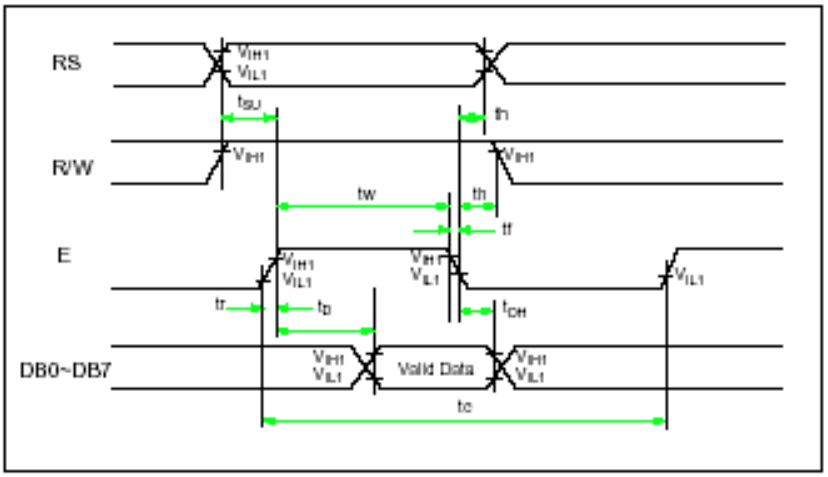
Mode	*Item*	*Symbol*	*Min*	*Typ*	*Max*	*Unit*
Write Mode (Refer to Fig-2.5)	E Cycle Time	tc	1400	-	-	ns
	E Rise / Fall Time	tr, tf	-	-	25	
	E Pulse Width (High, Low)	tw	400	-	-	
	R/W and RS Setup Time	tsu1	60	-	-	
	R/W and RS Hold Time	th1	20	-	-	
	Data Setup Time	tsu2	140	-	-	
	Data Hold Time	th2	10	-	-	
	E Cycle Time	tc	1400	-	-	

Read Mode (Refer to Fig-2.6)	E Rise / Fall Time	tr,tf	-	-	25	ns
	E Pulse Width (High, Low)	tw	400	-	-	
	R/W and RS Setup Time	tsu	60	-	-	
	R/W and RS Hold Time	th	20	-	-	
	Data Setup Time	tD	-	-	360	
	Data Hold Time	tDH	5	-	-	

(VDD = 2.7 to 4.5 V, Ta = -30 to +85°C)



Write Mode Timing Diagram



Read Mode Timing Diagram

9.4 Fixed Cellular Terminal Application {FCT.sc}

```
char KEY_IN2 = 10;
char KEY_IN3 = 11;
char KEY_IN4 = 12;
char RI = 1;
char DTR = 2;
char DCD = 3;
char DSR = 4;
char CTS = 5;
char CharTable[20] = {1,2,3,0x0a,0x0b,4,5,6,0x0c,0x0d,7,8,9,0x0e,0x0f,0x2a,0,0x23,0x12,0x13};

main()
{
        int val, aterr, resCmdSize;
        int i; /*counter for keyread loop*/
        char resCmd[20];
        char resndCmd[30];
        char sndCmd[30];
        char valstr[2];
        char PREVKEYPRESSED = 0;
        char CALLING = 0;

        /*setup All Key pins*/
        spc(RI,0); /* turn off RI */
        spc(DTR,0); /* turn off DTR */
        spc(DCD,0); /* turn off DCD */
        spc(DSR,0); /* turn off DSR */
        spc(CTS,0); /* turn off CTS */
        io(4,KEY_IN2,0); /*switch in I2*/
        io(4,KEY_IN3,0); /*switch in I3*/
        io(4,KEY_IN4,0); /*switch in I4*/

        valstr[0] = '\0';
        valstr[1] = '\0';
        sndCmd[0] = '\0'; /*NUL terminate send string*/
        resndCmd[0] = '\0'; /*NUL terminate send string*/
        aterr = atcrt(); /*AT channel setup */
        scpy(sndCmd, "ATD");

        LCDinit(); /*Setup LCD */

        val = kyc(0xFF, 1); /*use maximal keyboard*/
        while(1)
        {
                val = kyr();
                if(val != 0xFF)
                {
                        if(!PREVKEYPRESSED)
                        {
                                PREVKEYPRESSED = 1;
                                prtf("key pressed = %x",val);
                                val = CharTable[val];
                                if((val < 0x0a) || (val == 0x2a) || (val == 0x23))
                                {
                                        if(val <0x0a)
                                        {
                                                itoa(val,valstr,2);
                                        }
                                        else
                                        {
```

```
                        *valstr = val;
                }
                LCDdata (*valstr);
                scat(sndCmd, valstr);
        }

        else if(val == 0x0a) /* SEND key*/
        {
                if(gtb(8)==1) /*incoming call so answer*/
                {
                        aterr = atsnd("ATA", resCmd, 3, 20,
                                &resCmdSize);
                        LCDcontrol(0x01);
                        LCDtext("Answering", 9);
                }

                else if(!(gtf(9))) /*outgoing call so dial number*/
                {
                        CALLING = 1;
                        LCDcontrol(0xc0);
                        LCDtext("Dial", 4);
                        scat (sndCmd, ";");
                        aterr = atsnd (sndCmd, resCmd,
                            slen(sndCmd), 20, &resCmdSize);
                        prtf ("\nsent AT command \n%s", sndCmd);
                        scpy(resndCmd, sndCmd);
                }
        }

        else if(val == 0x0b) /* REJECT key*/
        {
                LCDcontrol(0x01);
                scpy(sndCmd, "ATD");
                aterr = atsnd ("ATH", resCmd, 3, 20, &resCmdSize);
        }

        else if(val == 0x0c) /* REDIAL key*/
        {
                if(!(gtf(9))) /*outgoing call so dial number*/
                {
                        CALLING = 1;
                        LCDcontrol(0x01);
                        LCDtext("Redial", 6);
                        aterr = atsnd (resndCmd, resCmd,
                                slen(resndCmd),
                        20, &resCmdSize);
                        prtf ("\nsent AT command \n%s", resCmd);
                }
        }
    }
}

else
{
        PREVKEYPRESSED = 0;
        prtf("No Key Pressed");
}

if(gtb(8)==1) /*incoming call so answer*/
{
        if(!CALLING)
        {
```

```
                                CALLING = 1;
                                LCDcontrol(0x01);
                                LCDtext("*Incoming Call*", 15);
                        }
                }

                else
                {
                        CALLING = 0;
                }
        } /* while (1) */

        aterr = atdst(); /*destroy AT channel*/
        val = kyd(); /*destroy keypad config*/

} /* main */

LCDdata(int Data)
{
        char Addr2;
        char DataWr[4];
        char HiBits;
        char LoBits;
        char Ack;
        Addr2= 0x70;
        HiBits = Data >> 4;
        LoBits = Data & 0x0f;
        DataWr[0] = HiBits | 0x60;
        DataWr[1] = HiBits | 0x20;
        DataWr[2] = LoBits | 0x60;
        DataWr[3] = LoBits | 0x20;
        i2w(Addr2,4,DataWr, &Ack);
}

LCDcontrol(int control)
{
        char Addr2;
        char DataWr[4];
        char HiBits;
        char LoBits;
        char Ack;
        Addr2= 0x70;
        HiBits = control >> 4;
        LoBits = control & 0x0f;
        DataWr[0] = HiBits | 0x40;
        DataWr[1] = HiBits;
        DataWr[2] = LoBits | 0x40;
        DataWr[3] = LoBits;
        i2w(Addr2,4,DataWr, &Ack);
}

LCDinit()
{
        char Addr2;
        char DataWr[4];
        char Data;
        char Ack;
        Addr2= 0x70;
        i2c(0);
        /* Set to 8 bit mode */
        /* And Write dummy 8 bit instruction 0001xxxx */
        LCDcontrol(0x31);
```

```
        /* Set to 4 bit mode and perform initialization */
        Data = 0x02;
        DataWr[0] = 0x42;
        DataWr[1] = 0x02;
        i2w(Addr2,2,DataWr, &Ack);
        i2w(Addr2,2,DataWr, &Ack);
        Data = 0x0c;
        DataWr[0] = 0x4c;
        DataWr[1] = 0x0c;
        i2w(Addr2,2,DataWr, &Ack);
        LCDcontrol(0x0f);
        LCDcontrol(0x01);
        LCDcontrol(0x06);
}

LCDtext(char *textstr, int textlen)
{
        char n;
        for(n=0; n<textlen; n++)
        LCDdata(textstr[n]);
}
```

10 Demo Board

The example covered here utilizes a Demo Board that can be plugged into the Development Board. The Demo Board is preconfigured thus:- LED jumpers 1-9 are connected, SWITCH jumpers 1-9 are disconnected. Jumpers I1, O1, O2, O3, O4 are connected, as is ADC1 to the THERM jumper. All other jumpers are disconnected.

10.1 Demo Board Information

This PCB (Demo Board) is designed as an expansion board to the Development Board. It plugs into the application connector X3 and predominantly allows access to the IOs and UART2/3.

10.2 Inputs/Outputs

IO1 to IO9 are each connected to a LED and a switch. Taking IO1 as an example; if configured as an input, the SW1 jumper needs to be added to

enable the use of switch IO1 to create an input. If configured as an output, the LED1 jumper needs to be added to enable the use of LED IO1 as an output indicator.

O1 to O4 are each connected to a LED. Taking O1 as an example; the O1 jumper needs to be added to enable the use of LED O1 as an output indicator.

I1 is connected to a switch. The I1 jumper needs to be added to enable the use of switch I1 to create an input.

Note : A number of the IOs have dual functions. When signals are used on the Demo Board, you must ensure that they are disconnected from other circuitry on the Development Board by the removal of the appropriate jumpers. For example, IO9 is also the UART1 RTS handshaking line. So if it is used as an IO on the Demo Board the RTS jumper must be removed.

10.3 UART's

X2 allows access to UART2 at RS232 levels. To enable system-status logging from the radio device on this port the SRVC jumper needs to be in place on the Development Board.

X3 allows access to UART3 at RS232 levels. RTS and CTS handshaking can be implemented on this port through the use of two spare IOs.

Note: When UART2 or UART3 is used on the Demo Board, the TD2/TD3 and RD2/RD3 jumpers on the Development Board must be removed to avoid conflicts.

10.4 Thermistor

By placing the appropriate jumper across the ADC header, one of the three ADCs on the radio device can be connected to the onboard thermistor (R43).

10.5 Miscellaneous

A number of other headers are available on the Demo Board. These allow access to the following signals.

- 2V7
- GND
- 3V6_VCC
- DAC
- HR_IN
- ON/OFF
- RD1
- SDA
- SCL

- TD1
- TO_IN
- UNASSIGNED1
- UNASSIGNED2
- UNASSIGNED3
- UNASSIGNED4

10.6 Demo Board Script {Demo_Board.sc}

When the script runs it configures the IO's. All the IO's connected to LED's are set as outputs to allow a "bargraph" like display. Input 1 (Switch I1) is used to switch the script function from "LED_Cascade()" to "ThermalSense".

When in "LED_Cascade()" mode, the IO's connected to the LED's are toggled so that a reciprocating LED cascade is seen.

When in "ThermalSense" mode, ADC1 reads the voltage at the boards thermistor, and a relative display of that reading is shown on the LED's using the ADCValToIO() function. If a set threshold reading is exceeded, an SMS is sent to alert of the temperature.

```
int ADC1 = 17;
int MINLIMIT = 112;
int HYSLIMIT = 120;
int NUMIOS = 13;
char Temp[24] = "Temperature Over Limit!";
char Number[12] = "012345678912"; /*Enter valid Phone number here*/
char SentAlready = 0;
int Count = 0;
int Up = 0;
char IOS[NUMIOS]= {0,1,2,3,4,5,6,7,8,13,14,15,16};

/* Function Flashes LEDs on IO's up in a LED_Cascade() */
LED_Cascade()
{

        /* set direction at endpoints*/
        if(Count == (NUMIOS-1))
        {
                Up = 0;
        }
        else if(Count == 0)
        {
                Up = 1;
        }

        if(Up)
        {
                /* Set next IO low*/
                io(1,IOS[Count++],0);
                /* Set Current IO high*/
                io(1,IOS[Count],1);
        }
        else
        {
                /*Set previous IO low*/
                io(1,IOS[Count--],0);
                /*Set Current IO high*/
                io(1,IOS[Count],1);
        }
}

/*Converts the ADC reading to a value that can be displayed on the IO LEDs*/
```

```
ADCValToIO(int Val)
{
	char i;
	int NewVal = Val;
	prtf("\n Val = %d",NewVal);

	/*Limit the Range to be displayed*/
	if(NewVal > 131)
	{
		NewVal = 131;
	}
	if(NewVal >= 105)
	{
		NewVal = NewVal-105;
	}
	NewVal = (NewVal >> 1);  /*divide by 2 to fit in 13 IO's*/
	/*NewVal now 0-8*/
	/*Set the IO LEDs */
	for(i=0;i<NUMIOS;i++)
	{
		if((i+2) <= NewVal)
		{
			io(1,IOS[i],0); /*Set IO's*/
		}
		else
		{
			io(1,IOS[i],1);
		}
	}
}

/*Function uses ADC to SHow LED temperature, and sends and SMS if Temperature at
Thermistor is over limit*/

ThermalSense()
{
	int Val;
	int err;
	/*read ADC1 connected to the thermistor*/
	Val = io(0,ADC1,0);

	/* Set the LEDs to reflect temperature*/
	ADCValToIO(Val);

	if(Val < MINLIMIT && !SentAlready)
	{
		prtf("\n Temp above Max Limit!");
		err = smss(Number, Temp, 129, slen(Number), slen(Temp));	/*Sent Text Alert*/
		if(!err)
		{
			SentAlready= 1;
		}
	}
	else if((Val >= HYSLIMIT) && SentAlready)
	{
		prtf("\n Temp dropped below Hysteresis Limit!");
		SentAlready = 0;
	}
}

/*Switches between LED_Cascade() and ThermalSense on Input 1 switch
main()
```

```
{
	/*For SMS*/
	atcrt();
	smsi(0,0);

	/*io config set up IOs as outputs for LEDs, and Input 1 for switch*/
	io(2,0,1); /*IO1*/
	io(2,1,1); /*IO2*/
	io(2,2,1); /*IO3*/
	io(2,3,1); /*IO4*/
	io(2,4,1); /*IO5*/
	spc(0,0); /*LED - IO6*/
	io(2,6,1); /*IO7*/
	io(2,7,1); /*IO8*/
	spc(6,0); /*RTS - IO9*/
	io(2,8,1); /*IO9*/
	spc(2,0); /*DTR - Input1*/
	spc(1,0); /*RI - O1*/
	spc(3,0); /*DCD - O2*/
	spc(4,0); /*DSR - O3*/
	spc(5,0); /*CTS - O4*/


	/*Main loop*/
	while(1)
	{
		/*read Input1*/
		if(io(0,9,0) == 1)
		{
			LED_Cascade();
		}
		else
		{
			ThermalSense();
			dlyms(2);
		}
		prtf("\nlooping!");
	}

}
```

11 MBUS - Metering Application

11.1 Overview

This example describes the use of SPI with embedded applications and how additional components can be added simply to the radio device's existing interfaces to provide an extra level of functionality. This is done in the context of an Application which uses MBUS as its communication mechanism, the Metering Bus standard (See Ref. 1 of this application note). The script below uses the Demo Board attached to the Development Board.

11.2 MBUS support in Embedded Applications

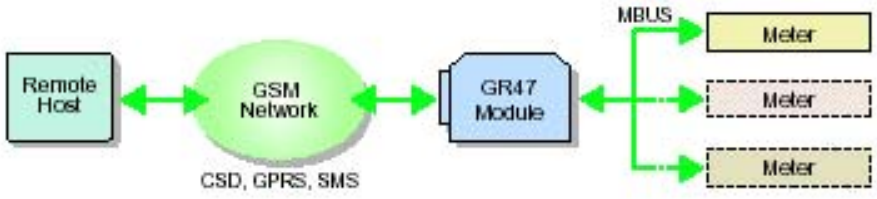
MBUS is a standard communications mechanism that covers low and high layers of the OSI stack model. In order to communicate MBUS packets physically from one device to another, there is a defined MBUS packet format. The data has to be sent as 1 start,1stop, 8 data bits and even parity. To do this, the radio device's programmable UART3 may be attached to a MAX3100 SPI-UART IC.

A software SPI implementation is provided that utilizes four I/O pins. This allows the communication of MBUS data to the MAX3100 SPI-UART IC, which then constructs the packets into the correct framing with the parity bits. This then can be communicated to a metering device. The embedded application has driver function calls for the MAX3100 device that allow simple configuration of and communication through the device. A further IO line is used to service interrupts from the MAX3100.

Only the physical layer data framing is done with the driver functions. The higher layers of the MBUS protocol need to be implemented in the script. Checking whether the incoming MBUS packets are valid and processing the buffers is also implemented at script level for complete flexibility.

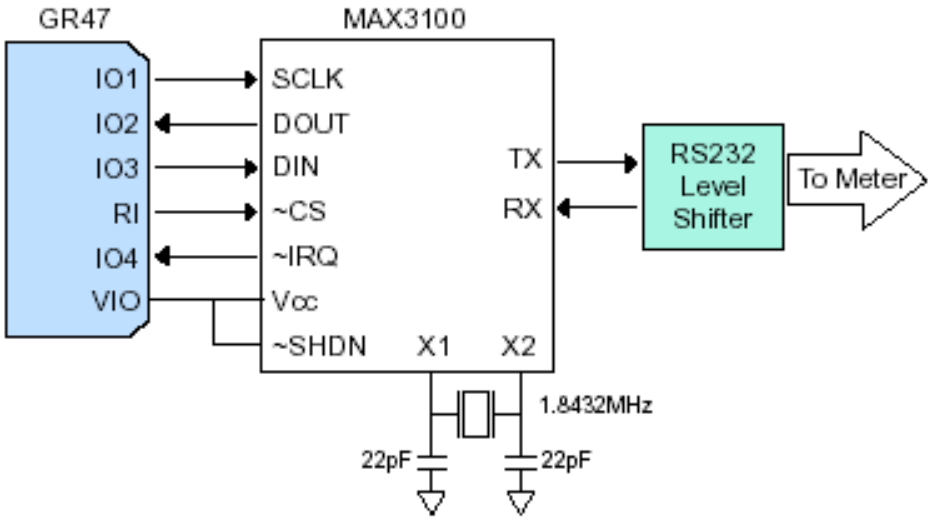
11.3 Implementation

The example application receives MBUS packets in a data call and sends them out to any connected metering device. The response packets are then read in and checked, before being communicated back up the data channel to the remote host.



11.4 Hardware Setup

In order to communicate with an MBUS device, the following setup is required.



A data enabled SIM is required, so that a CSD call can be made from a remote host to the radio device.

11.5 The Script

The fully commented script listing can be found below. For full descriptions of the individual script function calls, please refer to the IDE help file.

The script application initially sits in a loop, waiting for an incoming data call that requests an MBUS session be setup.

Once a call is received and checked to be from the correct number, the module answers the call and calls the DoMBUS() function. This function creates a channel. The channel goes to on-line mode and can carry the MBUS traffic. Data is received from the channel, checked to be valid MBUS data by the GetMBUSData() function and sent forward to the MBUS slave device via the M3100. The response data is received (must be received within 1 sec timeout) and transferred back up the channel in the same manner. In this way, the remote host can talk with one or more connected MBUS slaves using a single radio device. The validation procedure ensures no invalid packets are received or sent.

When the communication is finished, the call is cleared and the channel is closed down. The script goes back to monitoring for an incoming CSD call to initiate the next data session.

11.6 Testing the Application

In order to confirm the working application, the RS232 outputs from the level shifters can be connected via a 9-pin D-type header to a PC Com port. A

suitable terminal application that can send data in hexadecimal (Hex) can be used, setting the UART configuration to the MBUS speed and parity settings. A shareware tool that can be used for Hex transfer is “RS232 Hex Com Tool” from www.viddata.com. The debug prints from the application can be monitored if the service pin is asserted on the radio device and UART2 is monitored at 115200 baud (8 data, 1 start, 1 stop bit). The script field for DATA_NUMBER will need to be modified to reflect the data calling number.

11.7 Flexibility

This application demonstrates the kind of simple transfer application that can be written for the radio device, whereby data in some form is received by the radio device, and is communicated across a different interface to the slave, and vice versa. All that is required is the code to transfer the data from one interface to the other. Possible modifications to this script include:

- Changing the communication mechanism from CSD to TCP/IP (GPRS based), or SMS.
- Changing the interface from MBUS to SPI, standard UART or I2C.
- Sourcing the data call *from* the radio device, triggered by an incoming SMS or call.

11.8 Metering Application Script {MBUS.sc}

```
/*globals*/
int MAXCFGWORD = 0x2CC4; /* Check this */
int MAXDATA = 30;
int CALL_STATUS = 12;/*byte is status register*/
int RINGING = 1;/*CALL STATUS value*/
char DATA_NUMBER[12] = “07867900940”;  /*change this to your number*/
int CALL_COUNT = 1000; /* wait for Data Connection Count */
int GETLOOPCNT = 100; /* check data call status every 100 loops */
int REC10MSCNT = 10; /* 100ms receive wait */
char Recp[261];
char iRec[261];
int st;

/*operates on Recp and iRec*/
GetMBUSData (int RcNotRsp)
{
	/*Get MBUS data from Channel or Device*/
	/*Contains MBUS packet validation algorithm*/
	int Size = 0;
	int index = 0;
	int di = 0;
	int len = 0;
	int cnt = 0;

	while(st != 0) /*Possibly check on data call status as well?*/
	{
		if(di >= Size)
		{
			Size = 0;
			if(RcNotRsp > 0)
			{
				Size = chr(1,iRec,255); /*read more data from channel*/
			}
			else
			{
				Size = mxr(iRec,261);
			}
			di = 0;
		}

		/*validate the MBUS packet*/
		if(Size > 0)
		{
			Recp[index++] = iRec[di++];
			if(Recp[0] == 0xE5)
			{
				len = 1;
				break;
			}
			else if(Recp[0] == 0x10)
			{
				if(index >= 5)
				{
					index = 0;
					if(Recp[4] == 0x16)
					{
```

```
                                        len = 5;
                                        break;
                                }
                        }
                }
                else if(Recp[0] == 0x68)
                {
                        if(index > 5)
                        {
                                int psz = Recp[1];
                                if(index >= psz + 6)
                                {
                                        index = 0;
                                        if(Recp[psz + 5] == 0x16)
                                        {
                                                                                len = psz + 6;
                                                break;
                                        }
                                }
                        }
                }
                else
                {
                        index = 0;
                }
        }
        if( cnt++ < GETLOOPCNT)
        {
                cnt = 0; /*check call status every 100 loops*/
                st = chsts(1) & 0x02;
        }
    }
    if(st == 0)
    {
        len = 0;
    }
    return len;
}

DoMBUS()
{
    int Sz;
    int Cnt = 0;
    /*start transmission */
    /* get whole MBUS packet from Data Channel */
    Sz = GetMBUSData(1);
    /* send bytes over uart */
    if(mxs(Recp,Sz) == Sz)
    {
        prtf("\n Sent data to Max3100");
    }
    Cnt = 0;
    while(gtf(MAXDATA) == 0 && Cnt < REC10MSCNT)
    {
        dlyms(2); /*wait 100ms for data*/
        prtf("\n wt resp!");
        Cnt++;
    }

    if( Cnt < 10)
    {
        /* receive whole MBUS packet from Max3100 */
```

```
                Sz = GetMBUSData(0);
                /* send bytes back to data channel */
                chw(1,Recp,Sz);
        }
        else
        {
                /*no response*/
        }
}

main()
{
        int InCall = 0;
        int NumBuf[13];
        int TmpBuf[255];
        prs(0);
        chcrt(1); /*Create a channel for send/rcv data*/
        prtf("\n Script Created!");

        /* Setup SPI bus and Max3100 interface */
        if(mxc(MAXCFGWORD)) /* Enable,Sync High, every 2 bytes*/
        {
                prtf("\n Max3100 Configured!");
        }

        while (1)
        {
                int i;
                /*wait for incoming call*/
                if(gtb(CALL_STATUS) == RINGING)
                {
                        mset(NumBuf,0,13); /*Clear number buffer*/
                        clip(NumBuf,12);  /* get incoming number*/
                        prtf("\n Number = %s",NumBuf);
                        if(scmp(NumBuf,DATA_NUMBER,12) == 0) /*if number matches*/
                        {
                                /*answer call*/
                                chw(1,"ata\n\r",5);
                                /* wait for data mode */
                                for(i=0; i< CALL_COUNT;i++)
                                {
                                        st = chsts(1);
                                        prtf("\n chsts = %d",st);
                                        if (st & 0x02) /* check second bit of status for DCD */
                                        {
                                                break; /* data carrier detect */
                                        }
                                        dlyms(2); /* wait 100ms */
                                }
                                /* clear AT response from channel*/
                                chr(1,TmpBuf,255);

                                if(i < CALL_COUNT)
                                {
                                        /*if count hasn't expired, set to in call*/
                                        prtf("\n In Call!");
                                        InCall = 1;
                                }
                        }
                }

                if(InCall)
```

```
                {
                        DoMBUS();
                        st = chsts(1);
                        InCall = st & 0x02;  /*Make sure still in data call*/
                }
                else
                {
                        prtf("\n waiting for Call!");
                        dlys(1);  /* poll every 1 second when out of call */
                }
        } /*end while*/
}
```

11.9 References

1. MBUS - A Documentation - www.m-bus.com
2. MAX3100 Component data sheet - www.maxim-ic.com

12 Using the Embedded Application TCP/IP Functions for Data Exchange

12.1 Overview of Embedded Applications TCP/IP

The TCP/IP features provided by the embedded application functions of the radio device are intended to provide a subset of the features normally available at the socket level when using a conventional TCP/IP stack, with some simplification and customization based on the specific features of the radio device.

The features allow the application-writer to create and destroy UDP and TCP sockets, to control underlying GPRS PDP contexts, to transfer data to and from the radio device, and to interrogate IP status information about the active link.

The socket interface is provided by a series of functions outlined below:

pdpa()	Activate and deactivate a PDP context for TCP/IP over GPRS
ipo()	Open a UDP or TCP socket for data transfer
ipc()	Close a previously opened UDP or TCP socket
tcpc()	Connect to a TCP server specifying IP address and port
tcps()	Send data over a previously connected TCP socket
tcpr()	Receive data over a previously connected TCP socket
udps()	Send data over a UDP socket
udpr()	Receive data over a UDP socket
ipi()	Obtain IP-related information associated with the GPRS link
iprh()	Perform a text-to-IP-address hostname resolution

For full details of these functions, their parameters and possible return values, refer to the syntax data in the M2*m*power IDE Help files.

The majority of the functions, with the exception of the tcpc() function, will only return once the requested operation is complete. More detail regarding tcpc() is provided in later sections of this application note.

12.2 Basic Usage of TCP/IP Features

12.2.1 Protocols

The radio device embedded application functions provide support for the IP, UDP and TCP protocols. The user has no direct control over the IP layer (for instance a raw sockets interface is not provided), it is simply used as a transport by the higher-level protocols.

UDP provides for fast connectionless, less reliable communications between the radio device and remote hosts; TCP provides slower but reliable, connection-oriented communications, with flow-control, sequence checking and reordering.

Whilst the lower-level stack provides support for ICMP (Internet Control Messaging Protocol) features, and ICMP packets influence the operation and performance of the lower-level TCP/IP stack, the application-writer has no direct access to any ICMP features.

12.2.2 GPRS Transport for IP

In order to use the embedded TCP/IP functions, a GPRS PDP context must be activated first, to provide the underlying IP transport. This should be done using the pdpa() function, not by using direct AT dial commands. The embedded applications TCP/IP cannot properly make use of a PDP context that has been created using the ATD command.

In order to activate a PDP context, the details associated with the context (such as APN) must have been previously established. This is achieved using the AT+CGDCONT command. Use of AT commands to define PDP contexts alongside TCP/IP functions is normal; it is the PDP activation and deactivation that should not be performed using AT commands.

Once the PDP context is active, a socket can be created to enable bi-directional communications using TCP or UDP.

12.2.3 Flow of TCP/IP Operations in a Script

The basic flow of the TCP/IP operations within a script will normally take the following form:

1. Define an appropriate PDP context according to Service Provider data
2. Activate the required PDP context
3. Create a socket
4. For TCP only, perform a Connect to a remote host
5. Send data or status information over the socket to a remote host
6. Receive data or status information over the socket from a remote host
7. Repeat steps 5 and 6 for as long as the connection is required
8. Once communications are complete, close the socket
9. Repeat steps 3 to 8 for communications with different remote hosts
10. Deactivate the PDP context

12.2.4 TCP Connect Operations

A TCP connect operation can take quite a long time to complete, depending upon the link performance, lost packets etc. Therefore the tcpc() function has been made non-blocking to avoid stalling the script for long periods.

A call to tcpc() will initiate a connection but return immediately, leaving the lower level system to connect as responses are received. If no connection is achieved within a timeout of approximately 75 seconds, an indication of the failure at the script level will occur when a send or receive is attempted on a socket for which the connection is not yet active. This means that the application-writer should do one of two things to ensure that send and receive operations do not fail because a connection has not yet completed, either

1. Before a send or receive operation check the connection status by using the gtb(TCP_STATUS_BYTE) function and checking against TCP_CONNECTED (where TCP_STATUS_BYTE = 14, TCP_CONNECTED = 2), or
2. Check the result code from a send or receive operation and if the code indicates CONNECTING (1) then retry the operation, with appropriate timeouts applied.

12.2.5 Testing Communications over TCP/IP

The TCP/IP stack supports ICMP operations, such as ping responses these influence the operation of the low-level stack. However, the application-writer cannot perform ping tests from within a script. The only method for testing whether a remote site can be accessed is to attempt either a UDP or TCP operation to the host.

12.3 General Restrictions

The TCP/IP interface supports a single socket meaning that the embedded application can have only a single active socket at any one time. Use of, for instance, a UDP socket and a TCP socket in the same application requires that the script closes one socket before attempting to open or re-open another. For the majority of applications, the module is only ever transferring data over a single socket, so the restriction will not cause problems.

The TCP/IP interface does not currently support a ‘listen’ facility. This means that the module cannot be configured as a TCP or UDP server waiting for incoming connections. This restriction has been imposed for three reasons:

1. Most GPRS service providers use Network Address Translation (NAT) at their access points, which means that incoming IP accesses to the module will be blocked at the access point, and hence will not be passed through to the radio device.
2. Where NAT is not used, there are far-reaching security and reliability implications for systems that offer open services on UDP or TCP ports. The limited resources within the radio device do not allow for firewall features to provide full protection against attack vulnerabilities, and the easiest way to avoid such attacks depleting or destroying a data link is to disallow unsolicited incoming connections entirely.
3. It is straightforward to provide facilities from the radio device that equate to a server function, whilst requiring the radio device to instigate the initial connection to the remote system, i.e. the radio device creates a socket connection to a remote site after which the remote host issues

requests to the radio device over the active socket, using the radio device as a pseudo-server.

12.4 Resource Restrictions

12.4.1 Packet Buffers

The TCP/IP system supports a maximum of six simultaneous packets of size 1-1536 bytes, plus an additional two packets of size 1537-3100 bytes. If, having assigned all of these buffers, additional packets are received, or queued for transmit, the packets will be silently dropped. The packet buffers are shared with the lower-level GPRS system, hence the limits apply to the total data being buffered within GPRS and TCP/IP software layers.

Due to the buffer considerations, it is strongly recommended to use TCP rather than UDP to transfer larger volumes of data, or any quantity of critical data. The likelihood of packet loss within the radio device when using UDP is quite high, even for infrequent ‘bursts’ of data transfer.

12.4.2 IP Fragmentation

The radio device stack supports IP fragmentation and will successfully reconstruct fragmented packets provided:

1. No individual fragment exceeds the maximum packet size of 3100 bytes
2. The total reconstructed size of the fragmented packet does not exceed 3100 bytes
3. The internal packet buffers are not exhausted during the period that the fragments are being received.

The TCP/IP stack will, especially during busy periods, buffer and consolidate transmit data. This will sometimes result in data being sent from the radio device in larger units than submitted by the application. However, the largest sent-packet size will not exceed the reported Maximum Transmission Unit (MTU) of the underlying link.

12.4.3 Performance

Both the GSM module and the underlying GPRS transport infrastructure impose performance restrictions that can influence the effective IP performance of the application such that throughput can not be guaranteed.

12.5 UDP Example Script {UDP_transfer.sc}

A simple example of a UDP data transfer script is listed below. The script creates a UDP socket, sends some start data and then sits in a receive loop until a '$' character is received, after which it closes the socket and exits.

```
int Err;
int Port = 3000;
int Address = 0x0A8402A3; /* 10.132.2.163  */
int RXTX_SIZE = 1000;
char RxTxBuf[RXTX_SIZE] = "Starting! ";
char Complete = FALSE;
int APPS_IP_ERROR_TRIGGER = 36;
int APPS_IP_ERROR_STATUSBYTE = 13;
int APPS_IP_DATA_RECVD = 13;
int APPS_IP_TCPSTATUS_BYTE = 14;

/* Reset the IP error flag by reading it */
gtf( APPS_IP_ERROR_TRIGGER );
Err = pdpa( 1, 1 );
prtf( "\n PDP activate result = %d\n", Err );
if ( Err == 0 )
{
        Val = ipi( 0 );
        prtf(" IP Address = %x", Val );
        Val = ipi( 1 );
        prtf( "\n DNS 1 = %x", Val );
        Val = ipi( 2 );
        prtf( "\n DNS 2 = %x\n", Val );
}
else
{
        prtf( "\n PDP activation failed!\n" );
        return;
}
Err = ipo( 0, &SckNum );
if( Err != 0 )
{
        prtf( " \n UDP Socket open failed!\n" );
}
else
{
        int len;

        prtf( "\n UDP Socket Opened!\n" );
        prtf( "\n Sending start data...\n" );
        len = 10;
        Err = udps( SckNum, Port, Address, RxTxBuf, len );
        while( !Complete && (gtb( APPS_IP_ERROR_STATUSBYTE ) == 0) )
        {
                /* Receive some data */
                if( gtf( APPS_IP_DATA_RECVD ) )
                {
                        prtf( "\n IP DATA RECVD" );
                        len = RXTX_SIZE;
                        Err = udpr( SckNum, &Port, &Address, RxTxBuf, RXTX_SIZE, &len );
                        if( Err != 0 )
```

```
                        {
                                prtf( "\n UDP receive error!\n" );
                        }
                }
                else
                {
                        prtf( “\nReceived %d bytes of data.\n”, len );
                        if ( RxTxBuf[0] == ‘$’ )
                        {
                                prtf( “\n Breaking out of receive loop!\n” );
                                Complete = TRUE;
                        }
                }
        }

        /* Log status monitoring */
        if( gtf( APPS_IP_ERROR_TRIGGER ) )
        {
                prtf( "\n IP ERROR = %d\n", gtb( APPS_IP_ERROR_STATUSBYTE ) );
        }
}
Err = ipc( SckNum );
if ( Err != 0 )
{
        prtf( “\n Socket close failed!\n” );
}
Err = pdpa( 0, 1 );
prtf( "\n PDP deactivate result = %d\n", Err );
```

12.6 TCP Example Script {TCP_transfer.sc}

A simple example of a TCP data transfer script is listed below. The script creates a TCP socket, connects to a remote site and then sits in a receive loop until a '$' character is received, after which it closes the socket and exits.

```
int Err;
int PORTNUM = 3000;
int IPADDRESS = 0x0A8402A3; /* 10.132.2.163  */
int RXTX_SIZE = 1000;
char RxTxBuf[RXTX_SIZE] = "Starting! ";
char Complete = FALSE;
int APPS_IP_ERROR_TRIGGER = 36;
int APPS_IP_ERROR_STATUSBYTE = 13;
int APPS_IP_DATA_RECVD = 13;
int APPS_IP_TCPSTATUS_BYTE = 14;
int TCP_NOT_CONNECTED = 1;
int TCP_CONNECTING = 2;
int TCP_CONNECTED = 3;

/* Reset the IP error flag by reading it */
gtf( APPS_IP_ERROR_TRIGGER );
Err = pdpa( 1, 1 );
prtf( "\n PDP activate result = %d\n", Err );
if ( Err == 0 )
{
	Val = ipi( 0 );
	prtf( " IP Address = %x", Val );
	Val = ipi( 1 );
	prtf( "\n DNS 1 = %x", Val );
	Val = ipi( 2 );
	prtf( "\n DNS 2 = %x\n", Val );
}
else
{
	prtf( "\n PDP activation failed!\n" );
	return;
}
Err = ipo( 1, &SckNum );
if( Err != 0 )
{
	prtf( " \n TCP Socket open failed!\n" );
}
else
{
	prtf( "\n TCP Socket Opened!\n" );
	Err = tcpc( SckNum, Port, Address );
	if( (Err == 0) || (Err == TCP_CONNECTING) || (Err == TCP_CONNECTED) )
	{
		while( !Complete && (gtb( APPS_IP_ERROR_STATUSBYTE ) == 0) )
		{
			int len;

			/* Receive some data */
			if( gtf( APPS_IP_DATA_RECVD ) )
			{
				prtf( "\n IP DATA RECVD" );
				len = RXTX_SIZE;
				Err = tcpr( SckNum, RxTxBuf, &len);
				if( Err != 0 )
				{
```

```
                        prtf( "\n *** Error in TCP Receive (%d). ***\n\n", Err );
                    }
                    else
                    {
                        if( gtb( APPS_IP_TCPSTATUS_BYTE ) == TCP_CONNECTING )
                        {
                            prtf( "\n Delaying while TCP Connect occurs...\n\n" );
                        }
                        else
                        {
                            prtf( "\n Received  %d bytes of data.\n\n", len );

                        }
                    }
                }

                /* Log status monitoring */
                if( gtf( APPS_IP_ERROR_TRIGGER ) )
                {
                    prtf( "\n IP ERROR = %d\n", gtb( APPS_IP_ERROR_STATUSBYTE ) );
                    Complete = 1;
                }

                if( gtb( APPS_IP_TCPSTATUS_BYTE ) == TCP_NOT_CONNECTED )
                {
                    prtf( "\n *** TCP Connection lost - dropping out! ***\n\n" );
                    Complete = 1;
                }
            }
        }
        Err = ipc( SckNum );
        if ( Err != 0 )
        {
            prtf( “\n Socket close failed!\n” );
        }
}
Err = pdpa( 0, 1 );
prtf( "\n PDP deactivate result = %d\n", Err );
```

12.7 TCP Send Function Script {TCP_send.sc}

It is important to note that when using tcps(), the intrinsic TCP send function, the application-writer must check the number of bytes sent on successful return from the function, because a successful return is possible with the number of bytes actually sent being less than the number requested. In this case it is the responsibility of the application-writer to ensure that the remainder of the data buffer is re-submitted to the function.

The following is an example of a TCP send script function that checks for and corrects problems when not all data requested is sent by the tcps() function.

```
TCPSend( char cSckNum, char *cpTxBuffer, int *ipLen )
{
	int MAX_TX_ATTEMPTS = 20;
	int TX_FAILED = -2;
	int TCP_BACKOFF_DLYS = 2;
	int iResult = 0, iInitLen = *ipLen, iSent = 0, iTxAttempts = 0;
	int iReqLen;
	char *cpBuffer;

	while ( (iSent != iInitLen) && (iResult == 0) )
	{
		iReqLen = iInitLen - iSent;
		cpBuffer = cpTxBuffer + iSent;

		iResult = tcps( cSckNum, cpBuffer, &iReqLen );
		while ( (iResult != 0) && (iTxAttempts < MAX_TX_ATTEMPTS) )
		{
			dlys( TCP_BACKOFF_DLYS );
			iResult = tcps( cSckNum, cpBuffer, &iReqLen );
			iTxAttempts++;
		}
		if ( iTxAttempts >= MAX_TX_ATTEMPTS )
		{
			return TX_FAILED;
		}

		iSent = iSent + iReqLen;
		if ( iSent != iInitLen )
		{
			dlys( TCP_BACKOFF_DLYS );
		}
		iTxAttempts++;
	}

	return iResult;
}
```

The parameters for the call to TCPSend are the same as for tcps(), but the length parameter is an input only. The function will not return until either all the data has been sent, or a failure has occurred. Obviously the values for back-off delay and transmission retries can be adjusted to suit the application.

This function assumes that the caller has already checked that the TCP socket is connected, or if not, that the connection will become active within the timeout/retry period.

12.8 Host Name Resolution

Host name resolution in a script is performed using the iprh() function. The application-writer should be aware that the name lookup is effectively a blocking function. The script interpreter process will be blocked until the lookup is completed. This can lead to long script processing delays if something with the name resolution fails.

The name servers used by the lower-level stack are usually obtained dynamically when a PDP context is activated. The active settings can be interrogated using the ipi() function. A DNS lookup has a minimum timeout of approximately 124 seconds. Hence if all DNS servers are inaccessible (up to 3 are supported), or if the domain name does not resolve, there can be an overall delay of between 125 and 140 seconds before the iprh() function returns. During this delay script operation will stall, therefore the use of unreliable DNS servers could cause long pauses in operation.

12.9 IP Status Flags and Bytes

There are two status bytes and one status flag associated with the TCP/IP features. These are interrogated using the gtb() and gtf() script functions respectively.

The IP status flag APPS_IP_ERROR_TRIGGER (36) is set whenever an error occurs in the lower level IP system. The flag remains set until it is read, and is reset upon reading. The error that gave rise to the flag is obtained by reading the status byte APPS_IP_ERROR_STATUSBYTE (13). If several IP errors occur before the status flag is set the last error will be reported in the status byte.

The TCP system has a separate status byte called APPS_IP_TCPSTATUS_BYTE (14) which reports the current status of the TCP connection. This status can indicate that TCP is not-connected, connecting, or connected.

12.10 Advanced Technical Details

This section lists a number of advanced technical points for users who wish to understand more of the fine details of the TCP/IP stack in the radio device. For most readers this information will not be relevant.

12.10.1 Time-to-Live (TTL)

The radio device IP stack uses a Time-to-Live (TTL) setting of 64. This figure is fixed as far as the application-writer is concerned; there is no high-level method for changing it. Many modern systems use a TTL of 128, but apart from the most complex of routing arrangements, a figure of 64 will be perfectly adequate.

12.10.2 DNS Name Caching Period

The TCP/IP stack of the radio device caches DNS name to address mapping data for a period of approximately 120 seconds after a successful lookup. During this period subsequent name lookups for the same host will be serviced from the cache with no query being sent to the servers.

A maximum of six resolved hosts can be held in the cache at any one time. If the cache is full and a new lookup is submitted, the new lookup will fail until such time as the oldest entry in the cache is deleted due to expiry of its timeout.

13 Simple Telematics Solution with Embedded Applications

13.1 System Overview

This application note illustrates how an embedded application can be created to provide a simple Telematics demonstrator.

The radio device is connected to a GPS receiver via UART3, a Telematics Core Service (TCS) is provided by an embedded application script described here.

The script can be triggered to route data from the GPS receiver via SMS on receipt of a command SMS. An Administrative Front End application or GSM handset can be used to issue the command, once the command has been accepted the application in the radio device will reply to the originator with an SMS containing positioning data captured from the GPS receiver.

The Administrative Front End application may process the data by plotting the position on a map for example.

The commands supported are:

- Request – send a single GPS update
- Schedule x – send GPS updates continually at ‘x’ second intervals
- Stop – stop the current schedule process

The system is illustrated in figure 6.1

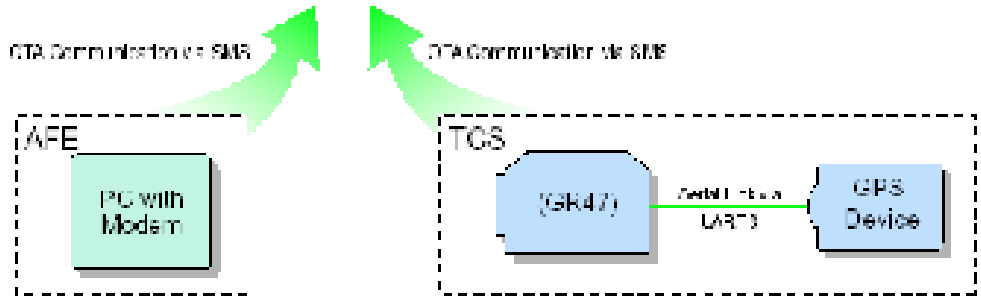
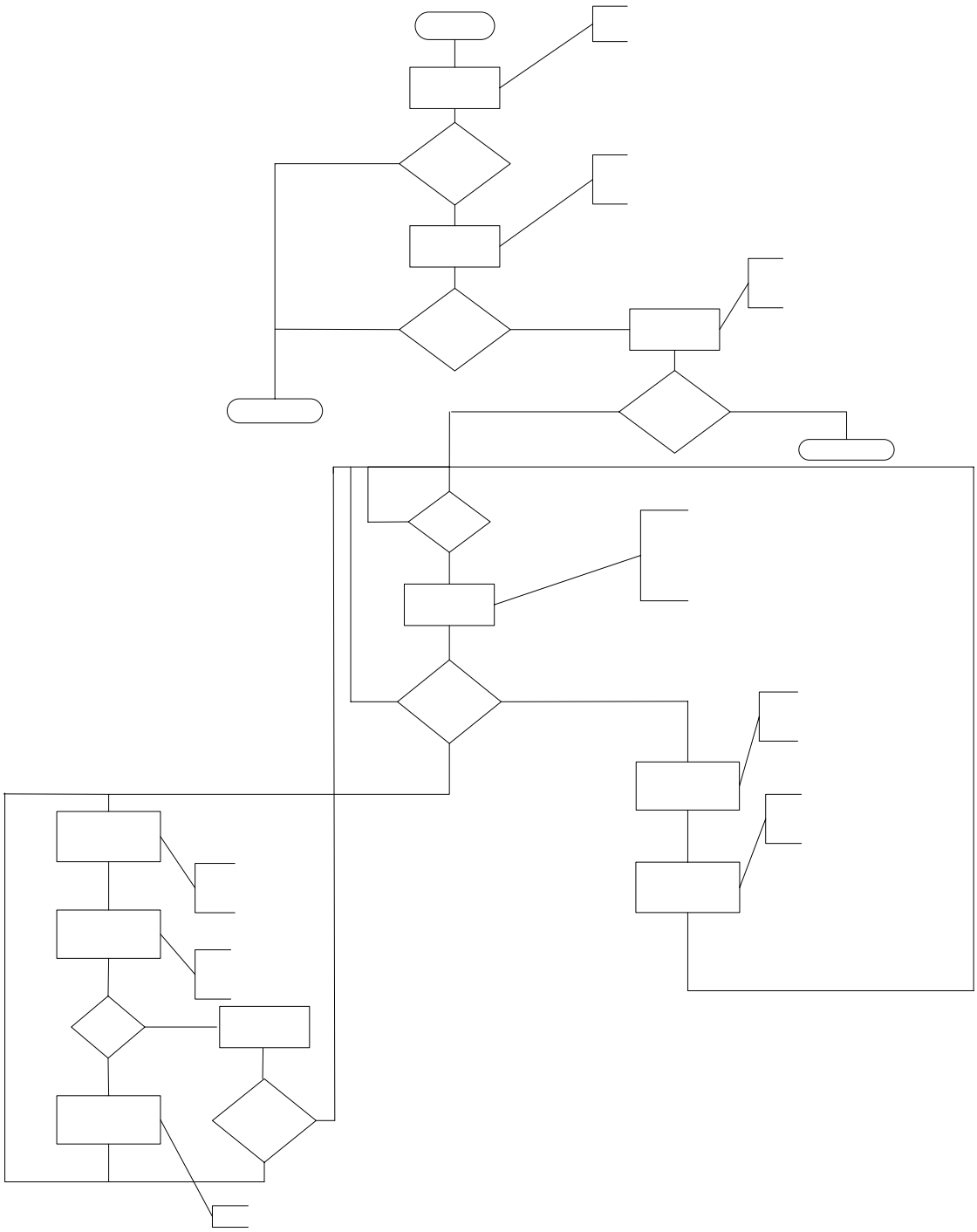


Figure 6.1 System Overview

13.2 TCS Script Flowchart

This flowchart below describes the TCS script.



13.3 TCS IFL Support

The intrinsic functions utilised by the application include the following :

General Hardware Library
gtf - Check for incoming SMS messages.
dlys - Set delay values including scheduling intervals.

AT Commands Library
atcrt - Create an AT Channel for SMS transactions.

SMS Library (OTA Communication)
smsi - Initialise the SMS ME and SM memory.
smsrs - Read an SMS message slot number.
smsrm - Read the SMS message data.
smsra - Read and store the SMS message address. This address becomes the address for sending position data back to an AFE.
smsd - Delete an SMS message once read.
smss - Send position data to an AFE.

GPS Library
sirfc - Initialise the SiRF binary protocol and GPS device to send binary messages at 19200 baud via UART 3.
sbfm - Request and filter data from the GPS receiver in SiRF Binary message MID 98 format.

13.4 Telematics Core Service Script {TCS_SMS.sc}

Below is a listing of the TCS application.

```
char *msgRequest = "Request";
char *msgSchedule = "Schedule";
char *msgStop = "Stop";

/*****************************************************
 * Name:                ReadSMS
 * Arguments:           char *d_p, int dLen
 *                      char *a_p, int aLen
 * Return:              int 1 or 0
 * Description:         Reads the first un-read SMS
 *****************************************************/
ReadSMS (char *d_p, int dLen, char *a_p, int aLen)
{
  int sNo = 0;

  if (gtf(29) > 0)
  {
    sNo = smsrs ();
    smsrm(d_p, dLen, sNo);
    smsra(a_p, aLen, sNo);
    smsd(sNo);
    prtf("\nReceived SMS [%s,%s]\n", d_p, a_p);
    return (1);
  }
  return (0);
}

/*****************************************************
 * Name:                SendNavData
 * Arguments:           char *adrs, int format
 * Return:              int 1 or 0
 * Description:         Send navigation data SMS.
 *                      format=0 Raw, format=1 ASCII
 *****************************************************/
SendNavData (char *adrs, int format)
{
  char pL_p[255];
  int pLSze = 0;
  int pLCSum = 0;

  sbfm(98, format, 0, pL_p, 255, &pLSze, &pLCSum);
  prtf("\nReceived NavData Format:%d Size:%d CSum:%d\nData[%s]\n", format, pLSze,
pLCSum, pL_p);

  prtf("\nSending SMS to [%s]\n", adrs);
  if (smss(adrs, pL_p, 145, slen(adrs), slen(pL_p)) > 0)
```

```
  {
    prtf("\nSMS Send Error\n");
    return (0);
  }
  prtf("\nSMS Sent OK\n");
  return (1);
}

/*****************************************************
 * Name:                ScheduleNavData
 * Arguments:           char *aMsg, char *sAdrs, int sInterval
 * Return:              None.
 * Description:         Request navigation if the SMS
 *                      message Schedule'x' received
 *                      Delay is 'x' second intervals
 *                      Max delay = 255 seconds
 *****************************************************/
ScheduleNavData (char *sMsg, char *sAdrs, int sInterval)
{
  while (1)
  {
    prtf("\nSending Nav Data on Schedule\n");
    SendNavData (sAdrs, 1);
    if (ReadSMS(sMsg, 160, sAdrs, 160) == 1)
    {
      if (scmp(sMsg, msgStop) == 0)
      {
        prtf("\nSchedule Stopped\n");
        return;
      }
      prtf("\nIgnored SMS Command[%s]\n", sMsg);
    }
    prtf("\nWaiting %d Seconds\n", sInterval);
    dlys(sInterval);
  }
}

main ()
{
  char sMsg[160];
  char sAdrs[160];
  char msg[16];
  int sRes = 0;

  prs(0);
  prtf("\tRunning:TCS Demo 14/07/03-11:40\n");
  prtf("\nInitilising SMS Memory\n");
  if ((atcrt() == 0)&&(smsi(1, 1) == 0))
  {
    /* create SIRF UART3 channel for Binary at 19200 */
    if (sirfc (0, 4) > 0)
    {
      while (1)
      {
```

```
        prtf("\nAwaiting SMS Command\n");
        if (ReadSMS(sMsg, 160, sAdrs, 160) == 1)
        {
          if (scmp(sMsg, msgRequest) == 0)
          {
            prtf("\nSending Nav Data on Request\n");
            SendNavData(sAdrs, 1);
          }
        else
        {
          sncpy(msg, sMsg, 8);
          msg[8] = '\0';
          if (scmp(msg, msgSchedule) == 0)
          {
            sRes = atoi(sMsg);
            prtf("\nUpdating Schedule to %d Seconds\n", sRes);
            ScheduleNavData(sMsg, sAdrs, sRes);
          }
        }
      }
      dlys(1);
    }
  }
 }
 prtf("\nInitialisation Error\n");
 atdst();
}
```